



Food and Agriculture
Organization of the
United Nations



INTERNATIONAL YEAR OF
FRUITS AND VEGETABLES

2021

**FRUIT AND VEGETABLES –
YOUR DIETARY ESSENTIALS**

The International Year of Fruits and Vegetables 2021
Background paper

Fruit and vegetables – your dietary essentials

**The International Year of
Fruits and Vegetables, 2021**
background paper

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Foreword

The United Nations has declared 2021 as the International Year of Fruits and Vegetables. The Year aims to raise awareness of the nutritional and health benefits of consuming more fruits and vegetables as part of a diversified, balanced and healthy diet and lifestyle as well as to direct policy attention to reducing loss and waste of these highly perishable produce items.

When we think of healthy eating, the first food items that often come to mind are fruits and vegetables – colourful, vitamin-, mineral- and fibre-rich, they are vital for the proper functioning of the human body. The benefits of consuming fruits and vegetables as part of a nutritious diet are vast. Fresh produce items are not only beneficial to consumers, but they also benefit the food system. The fruit and vegetable sector contributes to increasing biodiversity, generating environmental sustainability, and improving the livelihoods of farmers and employees operating along the value chains.

Low availability, due to challenges in production (for example, labour intensity), transport and trade, and high

prices for quality products make fruits and vegetables inaccessible to many, especially in developing countries. Some areas of the world face limited availability and access to these foods.

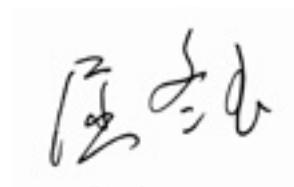
Fruits and vegetables are highly perishable products, and this can cause high levels of food loss and waste at every step of the value chain, starting at the farms. Given that many fruits and vegetables are consumed raw or uncooked, they may also pose a risk for foodborne illnesses linked to pathogen contamination and food safety risks due to chemical contamination.

Therefore, it is crucial to look at the fruit and vegetable sector holistically as an integral part of the food system, going beyond nutritional benefits, and to also examine their social, economic, and environmental benefits. Different actors can contribute to making fruits and vegetables more accessible, affordable and available. Investing in the cold chain, research and development, and digital innovation can help improve the sector substantially.

This publication seeks to draw attention to actions and systematic approaches

that must be taken throughout the fruit and vegetables food system to ensure their safety for consumption and to deliver better nutritional outcomes and healthy diets for all.

This publication will help to stimulate an interesting discussion about the fruit and vegetable sector for the observance of the International Year and beyond.

A square box containing a handwritten signature in black ink, which appears to be 'Qu Dongyu'.

QU Dongyu
FAO Director-General

Fruit and vegetables

Essential for healthy lives

Green, yellow, orange, red or purple: fruit and vegetables keep us healthy and add variety, taste and texture to our diets. Even if you eat rice or bread every day, you probably vary the types of fruit and vegetables you consume. A monotonous diet is not only unhealthy for humans: it is also unhealthy for the planet because it can result in monocultures and a loss of biodiversity.

Yet most of us do not eat enough fruit and vegetables. The World Health Organization (WHO) recommends consuming at least 400 g each day to reap their health and nutrition benefits. In 2017, some 3.9 million deaths worldwide were attributable to not eating enough fruit and vegetables (WHO, 2019). Insufficient intake of fruit and vegetables is estimated to cause around 14 percent of deaths from gastro-intestinal cancer worldwide, about 11 percent of those due to ischemic heart disease, and about 9 percent of those caused by stroke (Afshin *et al.*, 2019).



2021 is the International Year of Fruits and Vegetables

In declaring 2021 as the International Year of Fruits and Vegetables, the United Nations (UN) General Assembly aims to raise awareness of the nutritional and health benefits of fruit and vegetables and their contribution to a balanced and healthy diet and lifestyle. It also hopes to draw attention to the need to reduce losses and waste in the fruit and vegetable



sector (UN, 2020) while delivering better on environmental outcomes. Action is needed at the country level to increase the production and consumption of fruit and vegetables and make them more economically accessible to consumers, while generating economic, social and environmental benefits in line with the Sustainable Development Goals.

The International Year of Fruits and Vegetables complements several other international initiatives that also support the Sustainable Development Goals that address nutrition, consumption, health as well as small-scale family farmer issues:

- The **Rome Declaration on Nutrition** and the Framework for Action (FAO and WHO, 2014).
- The UN **Decade of Action on Nutrition** (2016–2025) (UN, 2016).

- The UN **Declaration on Rights of Peasants** and Other People Working in Rural Areas (UNHRC, 2018).
- The UN **Decade of Family Farming** 2019–2028 (UN, 2018).
- WHO's Global Strategy on **Diet, Physical Activity and Health** (WHO, 2004).

The diverse range and characteristics of fresh fruit and vegetables and their inherently perishable nature warrants specific attention to their conditions of production, agronomic management, pest and disease control, harvesting techniques and postharvest handling systems. The UN General Assembly's resolution also highlights various cross-cutting issues and factors to be addressed during the International Year of Fruits and Vegetables.

Small-scale producers. Fruit and vegetables are grown by small-scale producers around the world, either for their own use or for sale. Small-scale producers supply the fruit and vegetable requirements of mass markets in most developing countries. Such farmers each produce relatively low volumes, leading to problems with reliability and quality. Nevertheless, there are clear opportunities for improvements in these areas.

Technologies. Technology and innovation are required at all stages in the fruit and vegetable supply chain, from production to consumption, to improve both quality and output. Improvements can range from simple farm-level technologies and

practices to more sophisticated digital innovations that help assure the safety and quality of fresh produce as it moves along the supply chain. Innovative approaches such as public-private partnerships can help generate growth and development in the sector.

Income and employment. Fruit and vegetables tend to be worth more per kilogram than other types of food (animal products are an exception). However, they may also require more labour than for many other types of food. This offers opportunities for actors throughout the chain to generate employment and income.

Gender and youth. Women produce much of the world's fresh produce, and they are often responsible for the harvesting, marketing and processing. As consumers, they often choose what items to buy and how to cook them. But women face disadvantages at all stages in the chain – as producers in their ability to access land, inputs and advice, as entrepreneurs in getting finance to develop their businesses, as workers in terms of fair payment for their work, and as consumers in terms of education about food and nutrition. The high value of fruit and vegetables and the potential for innovation open exciting opportunities for young people to become involved in production and other aspects of the value chain.

Policy. Food policies tend to be tailored to the needs of staple crops. Fruit and vegetables have been relatively neglected in terms of policy attention, funding, research and extension, and support for agribusinesses.

What are fruit and vegetables?

There is no widely accepted definition for either fruit or vegetables. The definition agreed to for the International Year of Fruits and Vegetables is as follows.

Fruit and vegetables are considered edible parts of plants (e.g., seed-bearing structures, flowers, buds, leaves, stems, shoots and roots), either cultivated or harvested wild, in their raw state or in a minimally processed form. Excluded are the following:

- Starchy roots and tubers such as cassava, potato, sweet potato and yams (although leaves of these plants are consumed as vegetables) .
- Dry grain legumes (pulses) unless harvested when immature.
- Cereals including maize (corn), unless harvested when immature.



Box 1. Sustainable Development Goals related to fruit and vegetables



SDGs **2 3**

Health benefits of fruit and vegetables

Harness the goodness

Fruit and vegetables have multiple health benefits. They strengthen the immune system, combat malnutrition and help prevent non-communicable diseases.

SDGs **2 3**

Diversified diet and a healthy lifestyle

Live by it, a diverse diet

Adequate amounts of fruit and vegetables should be consumed daily as part of a diversified and healthy diet.

SDGs **2 8 12 13 14 15**

Food loss and waste

Respect food from farm to table

Fruit and vegetables are worth more than their price. Maintaining their quality and assuring their safety across the supply chain, from production to consumption, reduces losses and waste and increases their availability for consumption.

Innovate, cultivate, reduce food loss and waste

Innovation, improved technologies and infrastructure are critical to increase the efficiency and productivity within fruit and vegetable supply chains to reduce loss and waste.

SDGs **1 2 12 15**

Sustainable value chains

Foster sustainability

Sustainable and inclusive value chains can help increase production, and help to enhance the availability, safety, affordability and equitable access to fruit and vegetables to foster economic, social, and environmental sustainability.

SDGs **1 2 3 4 5 8 11 12 15**

Highlighting the role of family farmers

Growing prosperity

Cultivating fruit and vegetables contributes to a better quality of life for family farmers and their communities. It generates income, creates livelihoods, improves food security and nutrition, and enhances resilience through sustainably managed local resources and increased agrobiodiversity.

- Nuts, seeds and oilseeds such as coconuts, walnuts and sunflower seeds.
- Medicinal or herbal plants and spices, unless used as vegetables.
- Stimulants such as tea, cacao and coffee.
- Processed and ultra-processed products made from fruit and vegetables such as alcoholic beverages (e.g. wine, spirits), plant-based meat substitutes, or fruit and vegetable products with added ingredients (e.g., packed fruit juices, ketchup).

Minimally processed fruit and vegetables have undergone procedures such as washing, sorting, trimming, peeling, slicing or chopping that do not affect their fresh-like quality (Gil and Kader, 2008). Minimally processed food retains most of its inherent physical, chemical, sensory and nutritional properties. Many such foods are as nutritious as the food in its unprocessed form (Parrish, 2014). Examples include sliced fruit, bagged fruit, vegetable salads, and frozen and dried fruit and vegetables.

Fresh versus processed

Unlike most other categories of food, fruit are normally eaten raw (uncooked form): either whole (berries) or after peeling them (oranges, bananas, papayas and mangosteens). Many types of vegetables are also often eaten uncooked, as in salads. Some

(such as green beans) must be cooked before they are eaten.

The International Year of Fruits and Vegetables focuses on fresh produce or minimally processed products. It nonetheless recognizes that the processed forms of fruit and vegetables are important for farmers' livelihoods and incomes, trade, food security and nutrition. Some varieties are grown specifically to be sold as fresh produce; others are destined from the start for the processing plant. Still others may go either way: they are sorted and graded before sale: the best items are sold fresh (which typically fetches the highest prices), while the rest goes for processing.

Many types of fruit and vegetables are processed to increase their shelf-life, year-round availability, or to increase their value. Minimal processing (see above) retains the inherent properties of the produce. Full processing, on the other hand, may include juicing, fermentation, pickling, or canning in brine, juices or syrups.



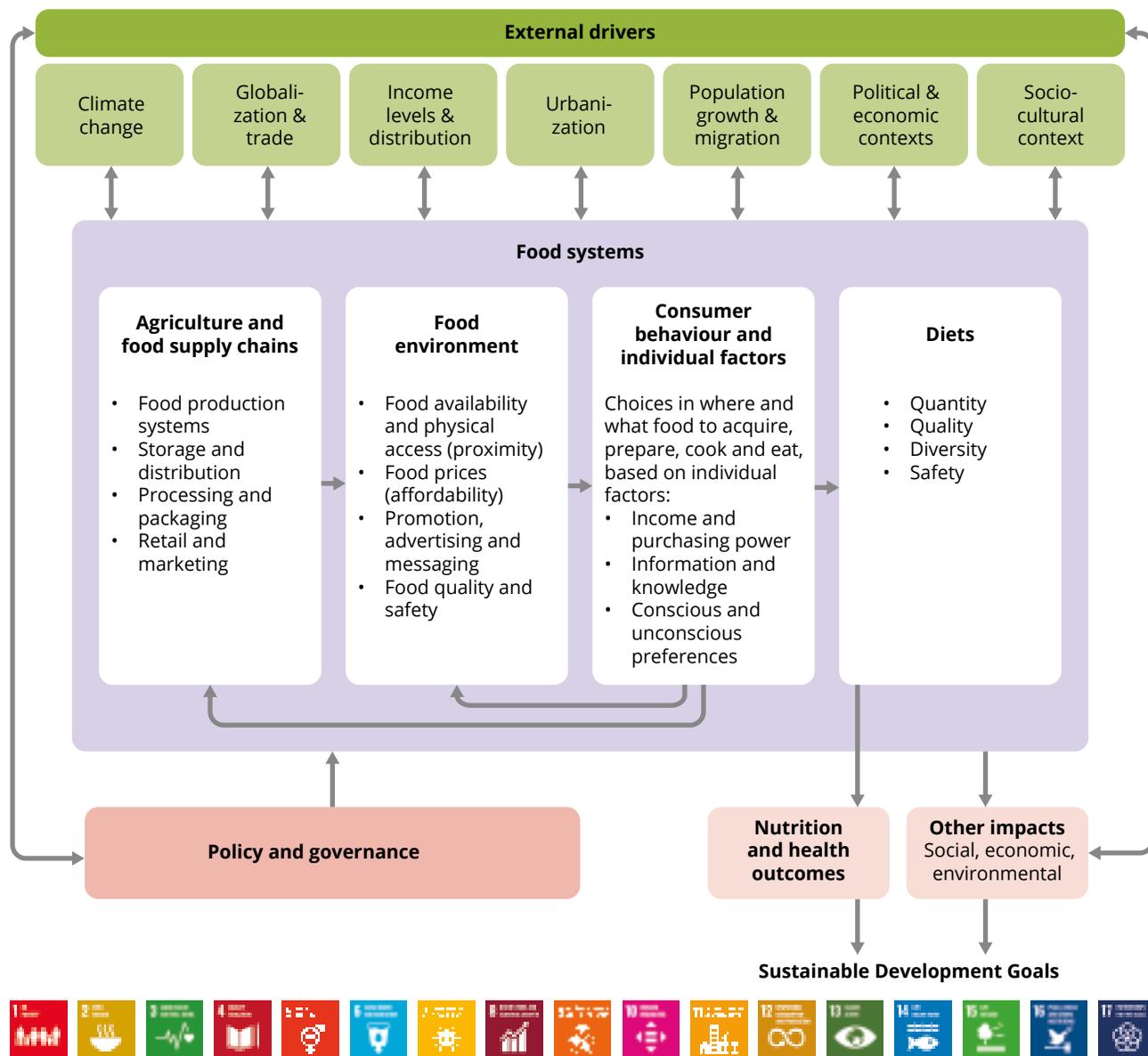


Figure 1. Food systems for healthy diets

Adapted from HLPE (2017), FAO (2020)

Sustainable Development Goals

Fruit and vegetable production is central to the livelihoods of many small-scale farmers. But it can damage the environment, including the soil, water and biodiversity. Chemicals used to ensure productivity and protect the crop from pests may pollute the environment. High levels of food loss and waste result from poor handling and the perishability of fresh produce, reducing the efficiency and sustainability of the system with potentially negative impacts on the environment and the natural resource base. Ensuring that fruit and vegetables contribute more to nutrition and health requires more comprehensive and holistic approaches. The supply of fresh produce must be made more efficient, inclusive and resilient (Box 1).

Transforming the sector: Adopting a food systems approach

It is widely accepted that our food systems are increasingly detrimental to both human and planetary health. Food systems are not delivering the healthy diets needed for nourishment. They result in the increasing prevalence of all forms of malnutrition (stunting, wasting, overweight, and obesity), all of which are exacerbated by the current COVID-19 pandemic. Other issues include rising populations and consumption, increasing urbanization, higher rates of non-communicable disease (WHO, 2019), decreasing arable land and water resources for agriculture, the effects of climate change and possible food shortages.

The Sustainable Development Goals support making the food system more productive, environmentally sustainable and resilient (Box 1). The elements of food systems – agriculture and food supply chains, food environments and consumer behaviour – require concerted action to ensure healthy diets are available, affordable, accessible, safe, culturally acceptable and appealing to all. Opportunities are needed throughout food systems to improve diet and nutrition outcomes (HLPE, 2017). This food-systems approach to better nutrition considers the food systems in its totality, taking into account all the elements, their relationships and related effects (Figure 1).

Beyond their relevance to diets and nutrition, food systems play an important role in promoting environmental sustainability (climate change adaptation and mitigation, biodiversity, soil and water degradation), inclusivity (viability for smallholder farmers, indigenous peoples, gender equity) and productivity (increased production of nutritious foods, economic development).

Transforming the fruit and vegetable sector requires a holistic and comprehensive approach that looks at the interconnectivity between demand, supply, socio-economic development and fruit and vegetable prices – a major determinant of consumer behaviour. Stronger linkages among the various actors and stakeholders across the system are needed to integrate sustainable practices in production, harvesting, postharvest handling, processing and consumption. Factors

to consider toward delivering on better nutrition while also creating a better environment, better production and better livelihoods include facilitating access by small-scale producers and agricultural enterprises to viable markets, assuring the safety and quality of fruit and vegetables along supply chains, applying innovation, reducing loss and waste, and reducing the energy intensity and ecological footprint of supply chains.

In this document

Chapters 2–5 address the four core elements of the fruit and vegetable sector. **Chapter 2** discusses delivering better and more efficiently on health and nutrition at the consumer end of the system. Eating fruit and vegetables is good for us, but few of us consume even the minimum amounts recommended by the World Health Organization. This chapter describes the current situation and presents some reasons for the shortfall.

Chapter 3 focuses on production. It presents the volume of production around the world, before focusing on the major types of producers: small-scale farmers, urban and peri-urban producers, and large-scale commercial growers. It then turns to the inputs needed to grow these crops, the environmental aspects of production,

and the policies and institutions that influence production.

Chapter 4 looks at the markets and value chains that link producers with consumers. It begins by focusing on international trade, which is important for certain crops and enables consumers to buy types of food they would not otherwise be able to get. It discusses contract farming, which offers ways for small-scale producers to participate in high-value markets. It then examines ways to link farmers to domestic markets (which account for the vast majority of the fruit and vegetables grown and consumed around the world), and how to add value to fresh produce. It concludes with a discussion of responsible business practices.

Chapter 5 focuses on quality, safety, loss and waste reduction. It highlights cross-cutting issues and the actions needed to assure sustainability and efficiency throughout the food system and to deliver safe, good-quality food.

Chapter 6 lists the key issues that must be addressed to move away from the current situation where elements of the food system operate independently. What is needed is a more sustainable and systemic approach, where the core elements are better linked with each other so they can deliver nutrition and health benefits and safeguard the environment.

Good for you

2

Health and nutrition benefits

Fruit and vegetables are a vital part of cuisines around the world. From *gado-gado* in Indonesia to sauerkraut in Germany and guacamole in Mexico, each country and region has its own favourite dishes. Rice, potatoes and bread are near-universal; it is our fruit and vegetables that help define our culture.

This chapter examines the consumption side of the fresh fruit and vegetable system (in other chapters we will look at what happens to get these foods to our tables). We start with the nutritional and health benefits of these foods. We then look at consumption levels around the world, and the reasons for the sad fact that most people do not eat enough of them to maintain a healthy life. The chapter ends with some suggestions as to how to change this.

Consumption

Parents around the world try to cajole their children to eat their greens or snack on fruit rather than junk food. They do so for a reason: fruit and vegetables are good for you.

The evidence is clear. Fruit and vegetables are an important part of a healthy diet. They help children grow and support body functions and physical, mental and social well-being at all ages. They can help prevent all forms of malnutrition (undernutrition, micronutrient deficiency, overweight and obesity) and reduce the risk of non-communicable diseases (Afshin *et al.*, 2019; WHO and FAO, 2005). Together with malnutrition, unhealthy diets are among the top-ten risk factors for disease globally.



Box 2. Colour is the key

The colours of fruit and vegetables are often linked to the nutrients and phytochemicals they contain (FAO, 2003)



Purple/blue

Antioxidant properties that can reduce the risks of cancer, stroke and heart disease.

Examples

- Beetroot, red cabbage, eggplant.
- Blackberry, blueberry, purple grape, plum, passionfruit.

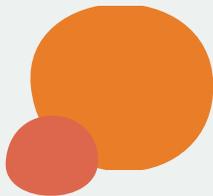


Red

Can help lower the risk of cancer and improve heart health.

Examples

- Red capsicum, radish, tomato.
- Red apple, cactus pear, cherry, red grape, red and pink grapefruit, red guava, raspberry, strawberry, watermelon.



Orange/yellow

Contain carotenoids that help keep eyes healthy.

Examples

- Carrot, pumpkin, squash.
- Apricot, grapefruit, lemon, mango, melon, nectarine, orange, papaya, peach, pineapple.



Brown/white

Phytochemicals with antiviral and antibacterial properties as well as potassium.

Examples

- Cauliflower, chive, garlic, ginger, leek, onion.
- Banana, durian, jackfruit, white peach, brown pear.



Green

Phytochemicals with anti-cancer properties.

Examples

- Asparagus, green bean, bok choy, broccoli, cabbage, green capsicum, cucumber, lettuce, peas, spinach.
- Green apple, avocado, green grape, kiwifruit, lime.

Almost all countries make dietary recommendations that include fruit and vegetables, using depictions such as triangles, pyramids and plates (see, for example, EU Science Hub). The recommendations vary from country to country, depending on what is locally available, affordable, and socio-culturally acceptable.

WHO currently recommends consuming at least 400 grams of fruit and vegetables each day – or five servings of 80 grams each (WHO and FAO, 2003). The optimum amount depends on various factors, including age, sex, and level of physical activity. All the guidance promotes a varied diet and a balance between different types of food. Fruit and vegetables are a vital part of this advice.

Benefits of eating fruit and vegetables

Consuming enough (or even more than the recommended amounts) of fruit and vegetables has many benefits (Box 2):

- **Children’s growth and development.** Fruit and vegetables are rich in Vitamin A, calcium, iron and folate, which can promote good health, strengthen a child’s immune system and help protect against disease, both now and in the future (Xin, 2016).
- **Longer life.** People who eat more fruit and vegetables live longer than those who do not, according to a large study in 10 European countries (Leenders *et al.*, 2013).
- **Better mental health.** Eating 7–8 servings a day (more than the recommended minimum of 5 servings) is linked to lower risk of depression and anxiety (Conner *et al.*, 2017).
- **Healthy heart.** Fibre and antioxidants in fruit and vegetables can help prevent cardiovascular disease (Wang *et al.*, 2014; Collese *et al.*, 2017; Miller *et al.*, 2017; Aune *et al.*, 2017).
- **Lower cancer risk.** In 128 out of 156 dietary studies, consuming fruit and vegetables was found to lower the risk of lung, colon, breast, cervix, oesophagus, oral cavity, stomach, bladder, pancreas and ovarian cancer (Boffetta *et al.*, 2010).
- **Lower obesity risk.** A number of studies have observed a lowered



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risk of adiposity and obesity in certain groups who consume fruit and vegetables (Ledoux *et al.*, 2011; Schwingshackl *et al.*, 2015).

- **Lower diabetes risk.** A systematic review and meta-analysis found higher green leafy vegetable and higher fruit intake was associated with a significant reduction in Type 2 diabetes risk. For every 0.2 serving/day of vegetable intake, there was a 13 percent lower risk of diabetes (Li *et al.*, 2014).
- **Better gut health.** A diet rich in fruit, vegetables and other high-fibre, plant-based foods improves gut bacteria diversity and tends to increase bacteria associated with anti-inflammatory compounds linked to improved metabolism. Higher consumption of fruit and vegetables has also been shown to decrease the prevalence of diverticulosis as well as other digestive problems

such as gas, constipation and diarrhoea (Klimenko *et al.*, 2018; Maxner *et al.*, 2020).

- **Improved immunity.** Adequate intakes of fruit and vegetables may reduce the severity of some infectious diseases. Though they will not protect you against a virus such as COVID-19, recovery from infectious disease is better when consuming fruit and vegetables than with diets low in this food group (Chowdhury *et al.*, 2020).

Consumption levels

Worldwide, we consume far less fruit and vegetables than the minimum total of 400 g recommended by WHO for a healthy diet. The amount of fruit and vegetables you need to eat depends on your age, sex, and level of physical activity. Many countries have developed additional recommendations for children, given the importance of fruit and vegetables for healthy growth and development.

On average, we consume only about two-thirds of the recommended minimum amounts of fruit and vegetables (calculation based on Afshin *et al.*, 2019). The quantities vary considerably: people in Central Asia, North Africa and the Middle East consume slightly more than the recommended minimum, while those in sub-Saharan Africa and Oceania consume only about one-third of this. Residents of the Caribbean consume the most fruit, while those in southern Africa consume the least.

Consumption of fruit and vegetables in sub-Saharan Africa is particularly low (Amao, 2018).

- In **South Africa**, a study of 3 480 adults aged 50 years or more found that 68.5 percent did not eat enough fruit and vegetables. This was especially true of Black African or Coloured men, men with low educational level, and those with low socio-economic status.
- In **Benin**, school-going adolescents consumed on average only 97 g of fruit and vegetables as compared to the generally recommended intake of 300 g for fruits and 150–225 g for vegetables for this age group.
- In Lagos, **Nigeria**, the same age group knew of the nutritional and health benefits, but only 5.5 percent of those interviewed consumed the recommended minimum amounts.

There is only a limited relationship between income levels at a regional level and the intake of fruit and vegetables. People in high-income Western Europe and Northern America consume only half of the ideal amounts, while those in North Africa and the Middle East consume larger quantities, even though incomes in this region are generally lower.

Overall, there is little apparent relationship between the consumption of vegetables with that of fruit. If we exclude those areas with low levels of consumption, there is a strong negative correlation between the intake of fruit and that of vegetables: the more fruit people consume, the fewer vegetables

they consume, and vice-versa. Possible reasons for this could be:

- Where incomes are generally low (as in sub-Saharan Africa and South Asia), people tend to spend their limited food budget on cheaper staple foods. Cultural preferences and the low availability of fruit and vegetables may also play a role.
- In other parts of the world, consumption levels are higher, but consumers still have a limited budget for fresh produce (or wish to consume only a certain amount of such items). They balance their spending or consumption: if they consume more fruit, they eat fewer vegetables. The levels of each depend on factors such as price, availability and culture.

Why do people not eat enough fruit and vegetables?

Eating behaviours are complex and shaped by interwoven physical, biological, psychological, historical, and cultural factors. While it is not possible to examine all the factors that influence fruit and vegetable consumption here, below are a few factors that emerged during a FAO/WHO workshop in 2020:

Availability. Many fruit and vegetables are seasonal and perishable and are not available year-round. High losses during harvesting, transport and storage reduce the quantities available in shops and markets. This is compounded by the lack of refrigeration and transport facilities,

Box 3. Consumption in sub-Saharan Africa

A study in 10 countries in sub-Saharan Africa (Ruel *et al.*, 2004) found that the expenditure for fruit and vegetables accounts for between 3 and 13 percent of the total household budget, or between 5 and 16 percent of the food budget.

As household incomes rise, demand for fruit and vegetables also rise, but at a slower rate than the income. Households headed by women tend to spend more on fruit and vegetables than do those headed by men.

Urban residents tend to eat more fruit and vegetables than do those in rural areas – but this is because urban residents tend to have higher incomes.

Controlling for income, better-educated people tend to consume less fruit and vegetables than those with less education. This is because the better-educated tend to work outside the home; they prefer processed foods that contain less fruit and vegetables.

warehouses and retail outlets, which shortens the shelf-life of especially perishable items. Breakdowns in supply chains disrupt the marketing of produce and reduce the incentives for producers to grow these crops. Low demand creates low supply, and vice-versa: a chicken-and-egg situation (see Chapter 3).

Affordability. Fruit and vegetables can be a relatively expensive part of the diet (Box 3). Many of the poor spend what food money they have on cheap, stomach-filling, energy-rich, staple carbohydrates such as rice or cassava. They add small amounts of vegetables and animal products for taste when available. Fruit can also be a luxury item, but may be affordable when production is at its peak. Those

with fields or gardens can grow and eat their own fruit and vegetables, but many crops are seasonal and perishable, and are therefore not always available.

Education and culture. Food is intensely cultural: our tastes are influenced by the culture we are brought up in and how we were brought up as children. Indeed, food is an important part of culture itself: what we cook and eat in part determines our identity. Immigrants prefer to eat food they are used to; immigrant communities frequent shops selling the products with which they are familiar. But cultures and diets sometimes change, and rising incomes and urban lifestyles with a preference for “convenience” are often associated with an increased intake of sugar, oils, animal products and highly processed foods, and lower consumption of fresh fruit and vegetables – a change known as the “global nutrition transition” (Caballero and Popkin, 2002; Popkin *et al.*, 2012).

Lack of knowledge. People may like (or dislike) fruit and vegetables for their taste but not know of their value for health and nutrition. The needs of children, teenagers, adults and the elderly differ, as do those of men and women. Women who are pregnant or lactating need extra nutrition, but they and their families may not be aware of this. People living with HIV/AIDS, and those with diabetes and other health problems, also need special diets. But nutrition and health-awareness campaigns are often poorly targeted and fail to match the physiological needs of these specific population groups.

Competition with alternatives.

Processed foods are backed by powerful advertising that present them as tasty and socially desirable. Aggressive marketing promotes unhealthy foods and beverages in schools, offices and shops. Sugary drinks are easier to buy and consume than freshly pressed juice; sweets and packaged snacks have a longer shelf life than fruit. Such foods compete with fruit and vegetables for the same dollar, euro, franc, peso, pound, rupee or shilling.

Food safety. Unlike many processed foods, fruit and vegetables have to be washed or peeled and perhaps cooked before they can be eaten. Eating contaminated fruit and vegetables may make you ill. The contamination may happen during production – from irrigation water, the soil, fertilizer or pesticides – or come from unsanitary processing and preparation (see Chapter 5).

National policies. Governments concerned about food security, the balance of trade and geopolitical concerns have focused a great deal of attention on staple crops and export commodities. They have devoted far less attention to fruit and vegetables. As a result, far fewer investments have been made by medium-sized and commercial farmers in their production. Trade policies have also promoted the influx of cheap, imported fruit and vegetables to the detriment of locally produced, indigenous varieties. This has contributed to the low consumption of neglected, underutilized but nutritious fruit and vegetables (see Chapter 4).

Improving health and nutrition

Alongside the current COVID-19 pandemic, we are also facing a pandemic of non-communicable diseases, many of them caused by poor nutrition (Allen, 2017). This requires decisive action. The policy areas needing attention include the following.

Promoting production. Interventions are needed to help small farmers produce more fruit and vegetables. That will mean improving agricultural extension services to promote good farm practices, good soil management and the availability of inputs such as seed and fertilizer. Attention is needed to empower women, who tend many a field and home-garden. Imports are important for supplying the nutrition needs of countries that do not produce enough fruit and vegetables domestically (FAO, 2018).

Improving availability. The availability of fruit and vegetables can be increased by improving the value chain





that connects growers with consumers (see Chapter 4). This includes transport, marketing, storage and processing facilities, labour resources and finance to make the value chain more efficient and to reduce losses and waste.

Improving affordability. Subsidies can increase the intake of fruit and vegetables (WHO, 2017).

Promoting consumption. Education and information are key to promoting fruit and vegetables as part of the diet. The poor consume less (or opt for cheaper alternatives) because they cannot afford them. In high-income countries, many people choose to eat unhealthy alternatives. Better targeted information and incentives can help change such behaviours.

Integrating nutrition in school curricula. Schools are an important

aspect of such promotional campaigns. Nutritional messages and horticultural production integrated in curricula can help children acquire life-long skills and promote the consumption of fruit and vegetables from the early years of life. School feeding-programmes, already important in the effort to end hunger, should be part of national education policies as well. Legislation can promote the inclusion of fruit and vegetables in school canteens, vending machines and procurement practices. Marketing restrictions on the sale near to schools of foods that are high in salt, sugar and trans-fat can help improve the school food environment.

Measuring nutrition. Further efforts are needed to measure the consumption of fruit and vegetables, along with other dietary components. Progress is being made. Two indicators are the Minimum Dietary Diversity for Women of Reproductive Age, and the Infant and Young Child Feeding Minimum Dietary Diversity (FAO and FHI 360, 2016). The former is included in the suite of nutrition indicators planned for around 90 countries that will conduct demographic health surveys.

Studies on nutrition campaigns have so far focused largely on content and process rather than on impact. A number of good practices have not yet been properly documented. Such studies are urgently needed.

Growing green

3

Sustainable production

Most fruit grow on trees – and trees have to be planted, tended and harvested.

Vegetables (most of which are annual crops) must be sown, transplanted, weeded, managed for pests and diseases, and harvested. Fruit and vegetable production tends to be labour- and skill-intensive. That generates employment, but also adds to the cost of production, pushing up prices of the output.

This chapter focuses on the production of fruit and vegetables. We start with an overview of production worldwide, in terms of commodities, regions and growth in the last two decades. We then examine three different types of producers: small-scale producers (who grow the majority of the world's fruit and vegetables), urban and peri-urban producers (who are frequently also small-scale producers), and large-scale commercial producers.

Next we turn to the farm inputs (seeds, water, fertilizers and pest management) and good farm practices. We then highlight selected environmental issues: resource use, climate change, neglected crops and wild species,

and the alarming loss of biodiversity threatening all fruit and vegetable species. Finally, we examine three aspects of policies and institutions that particularly affect the production end of the value chain: research and technology development, extension services, and rural infrastructure.

Production

In 2018, the world produced a total of 868 million tonnes of fruit and 1 089 million tonnes of vegetables (FAOSTAT).



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Fruit, million tonnes

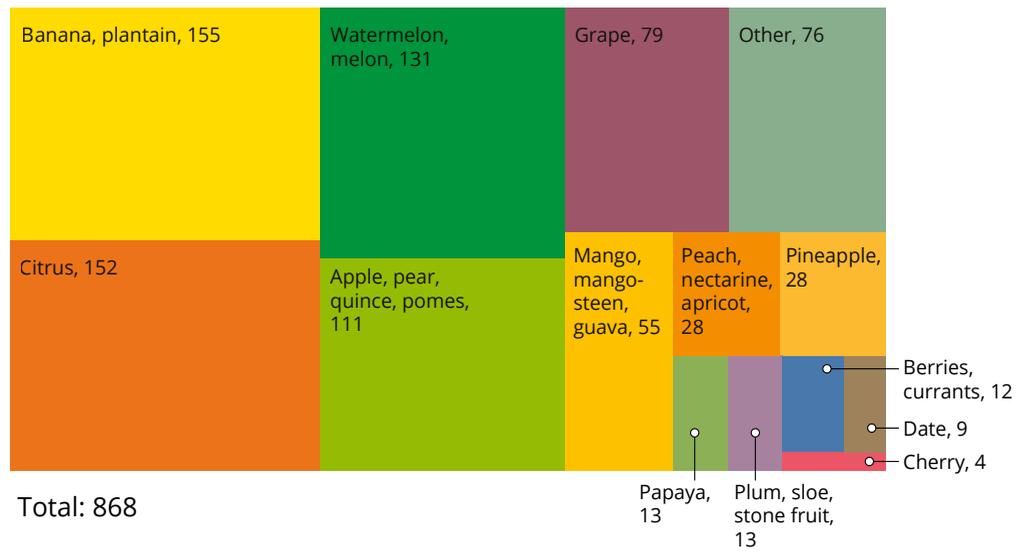


Figure 2. World fruit production by commodity, 2018

Source: FAOSTAT

Vegetables, million tonnes

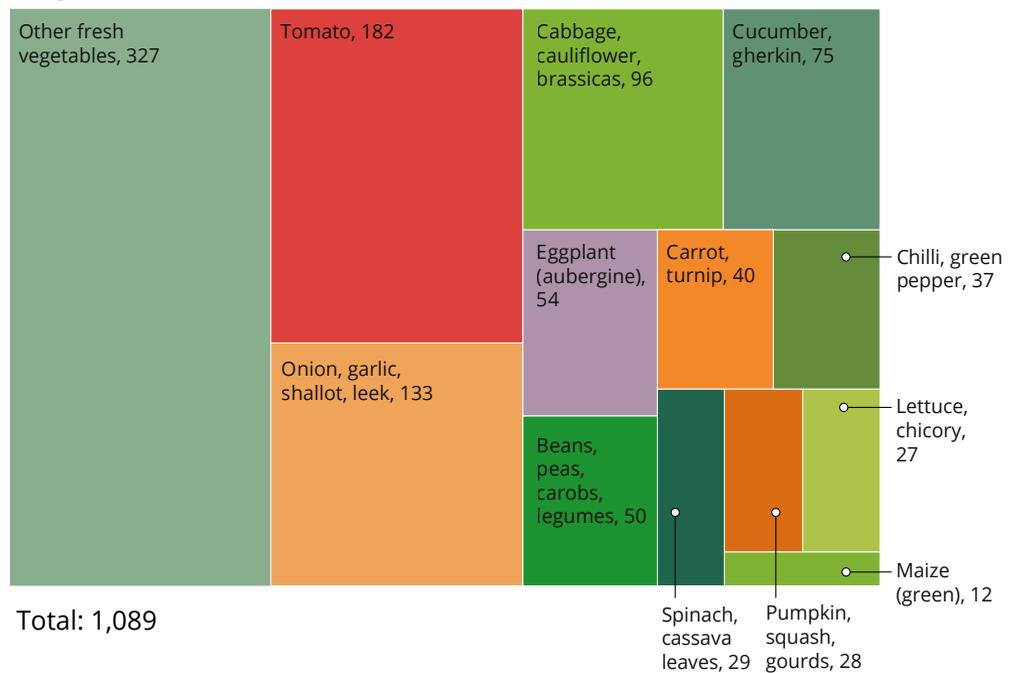
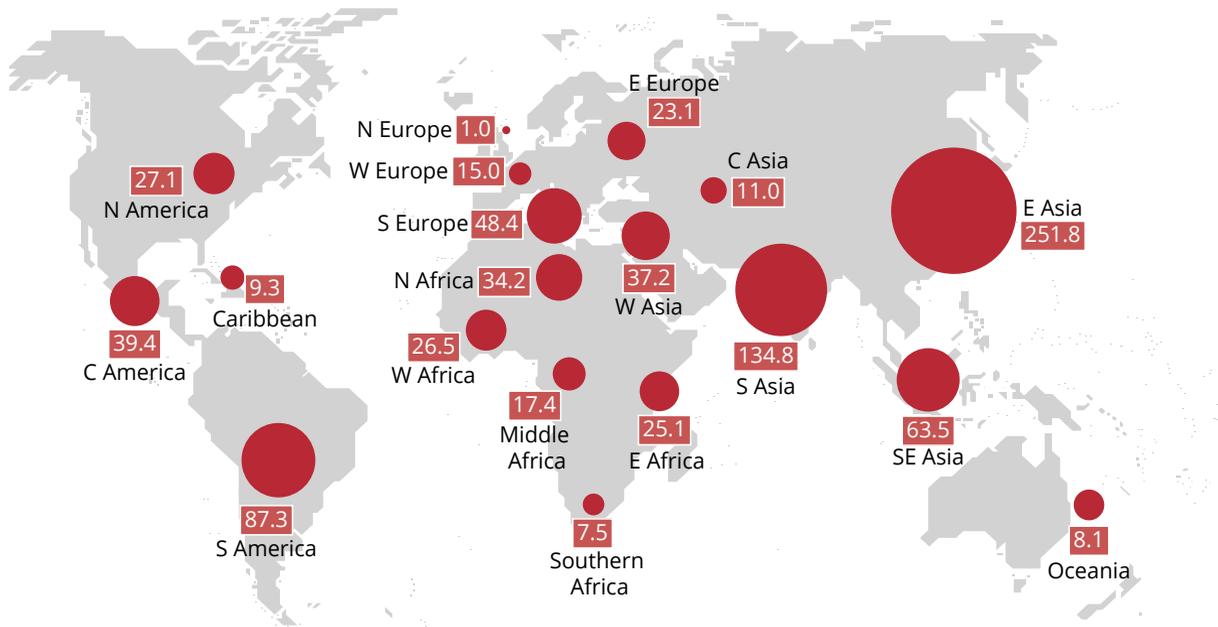


Figure 3. World vegetable production by commodity, 2018

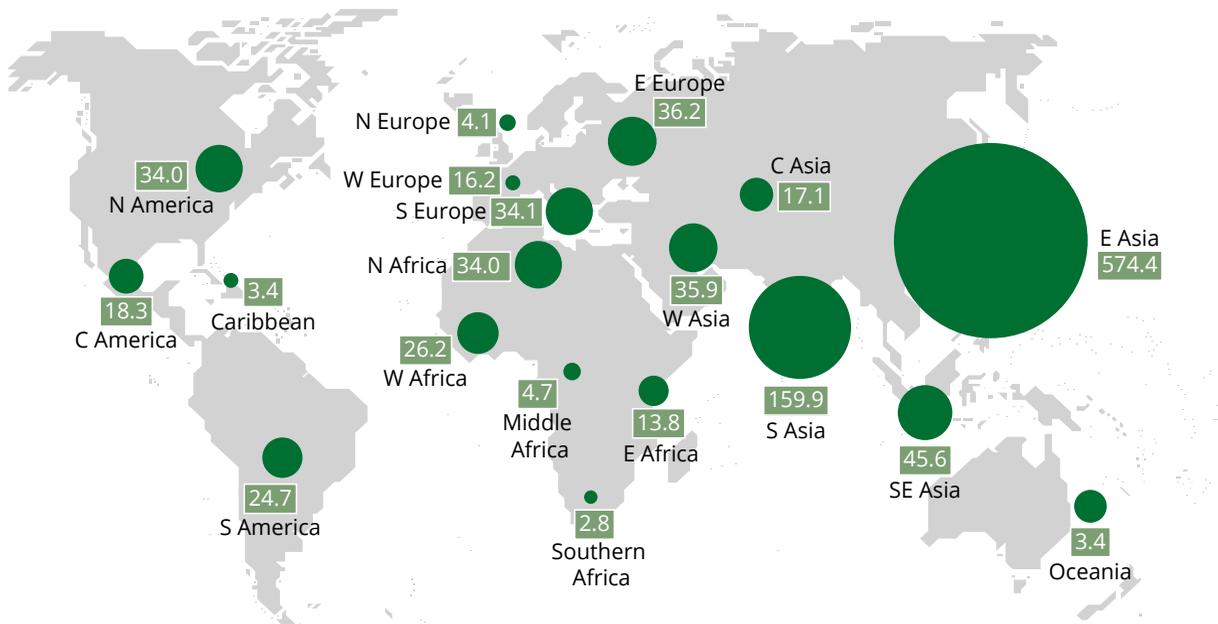
Source: FAOSTAT



**Fruit production, 2018
million tonnes**

Figure 4. World fruit production by region, 2018

Source: FAOSTAT



**Vegetable production, 2018
million tonnes**

Figure 5. World vegetable production by region, 2018

Source: FAOSTAT

The main **fruit** in order of importance were banana, citrus (orange, tangerine, mandarin, lemon, grapefruit, etc.), melons, apple and grape (Figure 2). “Other” fruit accounted for 76 million tonnes, reflecting the wide range of different types of fruit that are grown around the world.

The main **vegetables** were tomato, various alliums (onion, garlic, shallot, leek), brassicas (cabbage, cauliflower, broccoli), and cucumber. But overall, “other” fresh vegetables are more important than any of these individual categories: nearly twice as many “other” vegetables were produced than tomatoes (Figure 3).

The world’s main producing region of both fruit and vegetables, by a long

way, is East Asia, followed by South Asia (Figures 4 and 5). Other major producing regions are South America, Southeast Asia and Southern Europe (for fruit), and Southeast Asia (for vegetables). Northern and Western Europe produce relatively little, so have to import much of what they consume (see Chapter 4).

Nonetheless, production statistics cover only a few of the many species of fruit and vegetables that are grown and consumed. A large proportion of the output of small-scale producers also does not appear in the official production and trade statistics. Home gardening and production for home consumption are vastly undocumented, so their impact is largely unknown. We need to better

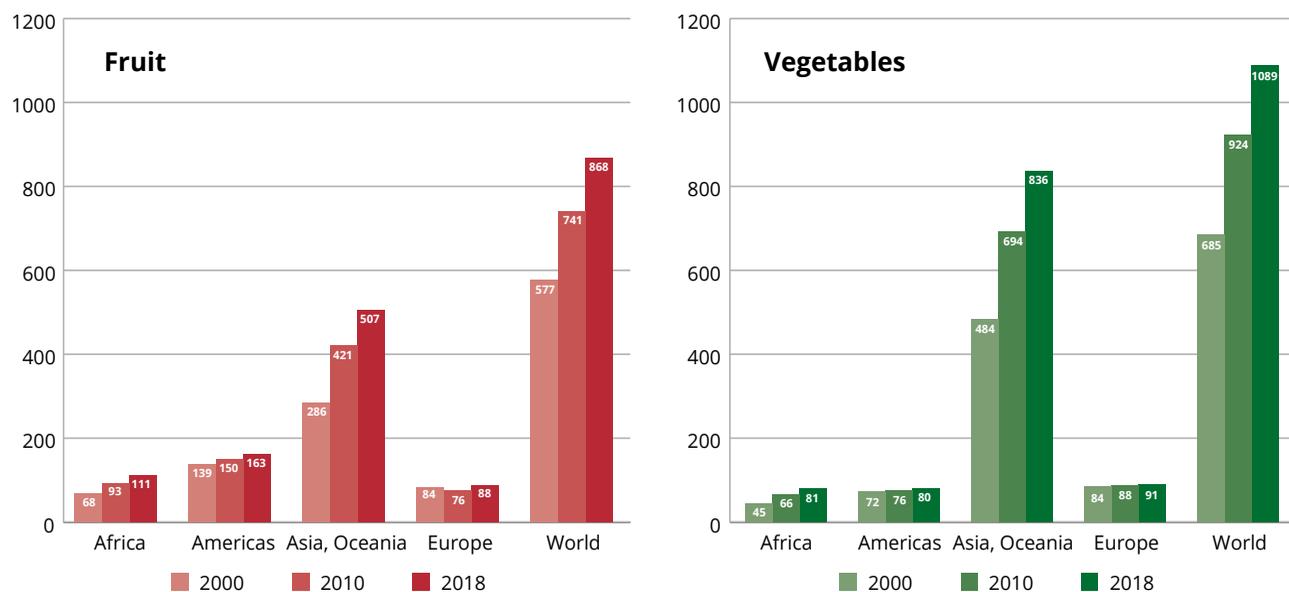


Figure 6. Change in production of fruit and vegetables, 2000–2018

Source: FAOSTAT

understand the diversity and reality of different production systems.

Worldwide production of both fruit and vegetables rose by about half between 2000 and 2018 (Figure 6). The biggest absolute increase was in Asia, especially East Asia (where China is by far the largest producer). In relative terms, the biggest increases were in Central Asia (where production of both fruit and vegetables more than tripled) and Central Africa (nearly triple the amount of fruit and double the volume of vegetables, though from a very low base). Production of vegetables also doubled in East and West Africa.

Production in some regions has stagnated or even declined: in Northern America and Southern and Western Europe (fruit and vegetables) and in Northern Europe (vegetables only).

The world is producing more fruit and vegetables – but still not enough. In 2000 world production totalled just 306 grams per person per day. By 2017 this had risen to 390 grams (FAO, 2020) – but this includes non-edible portions such as the core and peel, as well as loss and waste, which are often very high. WHO recommends that people should eat at least 400 grams of fruit and vegetables a day (Mason-D’Croz *et al.*, 2019).

Distribution and access problems mean that many people cannot get the types or amounts of food they need (Chapter 4). A sizeable proportion of the harvest is lost or wasted before it reaches consumers’ plates (Chapter 5). Climate change and a lack of water for growing crops will make it

difficult to produce enough to meet the WHO’s recommended daily intakes (Mason-D’Croz *et al.*, 2019). And the 400-gram-a-day figure is an average: the actual recommended amounts depend on factors such as age and sex (Chapter 2). Making sure that everyone can get enough fruit and vegetables will require improvements along the entire value chain, from production to processing, marketing, and finally consumption.

The umbrella term “fruit and vegetables” covers an incredible range of species, varieties, cropping systems, agro-climatic conditions, and farm and market types. No single production approach can be used for them all. For production to be sustainable, the practices and technologies must be adjusted to the local context.



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Producers

Small-scale producers

Family farmers, who are often (but not always) small-scale producers, account for 80 percent of the world's food in value terms (FAO and IFAD, 2019), as well as a large share of fruit and vegetables.

Worldwide, over 50 percent of the fruit and vegetables are grown on farms smaller than 20 hectares (most of which are family farms). In developing countries, such farms grow the vast majority of horticultural produce – over 80 percent in most of Asia, sub-Saharan Africa and China (Figure 7).

- In **Cambodia**, fruit and vegetables are the second most important commodity group after rice in value terms and provide the main additional source of income for most households in the country (Altendorf, 2018).
- Around 80 percent of avocado production in **Mexico** is estimated to be carried out by small-scale farmers (Altendorf, 2019).
- Some 200 000 rural families are reported to be directly involved in, and benefiting from, banana production in **Guatemala** (Altendorf, 2019).

In Europe and North and Central America, medium-sized farms of

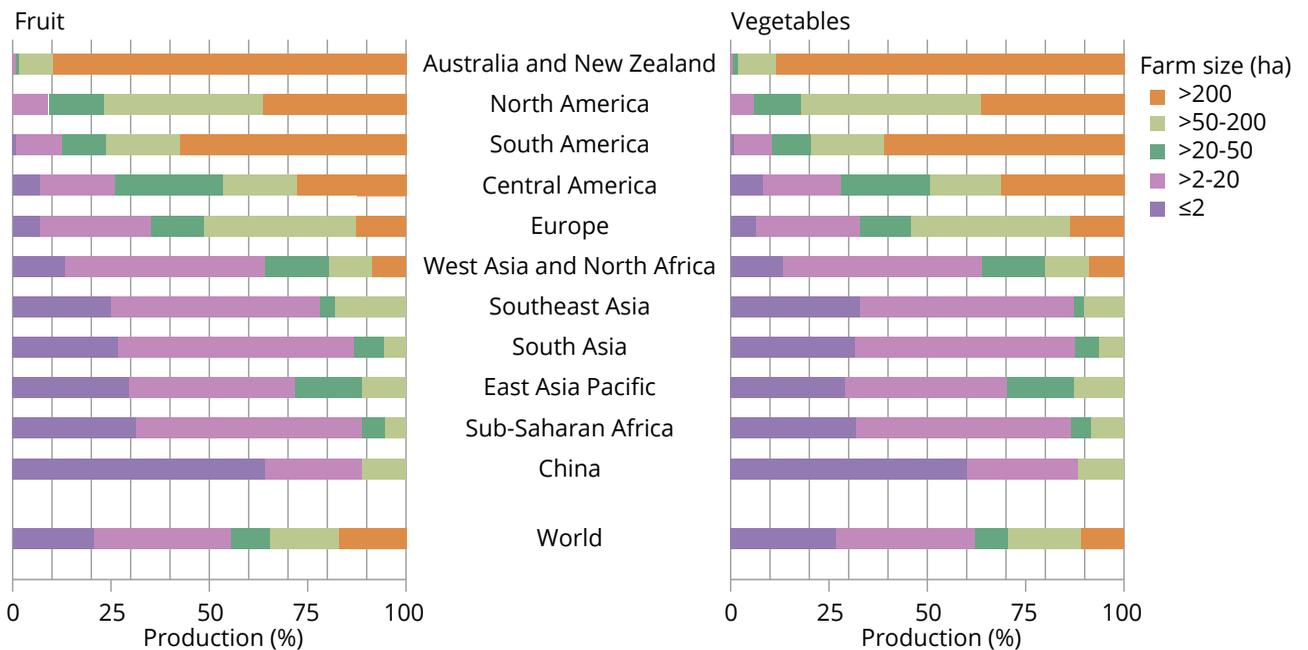


Figure 7. Production of fruit and vegetables by farm size and world region

Adapted from Herrero *et al.*, 2017.

20–200 hectares are more important, while it is only in South America and in Australia and New Zealand that farms over 200 ha dominate.

Fruit and vegetables typically are more profitable than staple crops for a given area of land. They also require more intensive management. That opens opportunities for small-scale farmers to take advantage of rising demand and to earn more by producing and marketing fruit and vegetables. Small-scale production also has the potential to protect the environment and ensure social equity (FAO, 2012). Women, in particular, can benefit as they are frequently engaged in fruit and vegetable production and marketing (Fisher *et al.*, 2018).

Small-scale family farms are often more diverse than larger farms, with a mix of staple crops, fruit, vegetables, other crops, and livestock. This mix allows them to spread their risk: if one crop fails, they have others to fall back on. Diversity also means ecological balance, with crop residues used to feed livestock and manure used to fertilize crops. Different crops harbour pollinating insects and beneficials that control pests.

Many countries are currently experiencing a decline in the numbers and diversity of insects, threatening the many fruit and vegetable crops that rely on insect pollination. The small size of many family farms can help preserve biodiversity. At the same time, diversified systems are more knowledge-intensive and require skills to manage them efficiently.

But small scale and a diversity of products makes it difficult for individual farmers to market their produce effectively. Marketing must therefore rely on farmers getting organized into groups or entering contract-farming arrangements with traders (see Chapter 4). As a group, farmers can perform collective actions such buying inputs, hiring services and selling their output. The group members can also swap ideas and experience, and they have a bigger chance of receiving technical advice.

Urban and peri-urban producers

Many of the smallest-scale producers are found in and around towns and cities. They include commercial growers who sell their output to local markets, as well as home-gardeners and community gardeners who grow produce for their own consumption or to share with friends and neighbours. Surplus produce is sometimes sold directly to consumers or to small-scale traders. These producers can increase the availability and access to fruit and vegetables for urban dwellers. The COVID-19 pandemic has highlighted the importance of local production (FAO, 2020).

Bad roads mean that highly perishable fruit and vegetables cannot be transported far. This is less of a problem for cereals or crops like cacao and coffee, which can be dried, bagged, loaded onto trucks and hauled off to distant markets. This is one reason intensive commercial horticulture tends to cluster around urban areas.

While growing fruit and vegetables in and near cities has advantages, it also brings risks – of pollution, contamination, and the loss of land to urban growth. In addition, in some countries urban agriculture does not fall under the responsibility of the ministry of agriculture, so growers cannot benefit from extension services or government-supported inputs (Aubry and Manouchehri, 2019; Taguchi and Santini, 2019).

Large-scale commercial producers

Larger-scale commercial producers of fruit and vegetables tend to focus on a relatively small range of major crops, such as tomatoes, bananas and pineapples. Many of these are destined for the export market or for industrial processing. Depending on the structure of the market, there may (or may not) be opportunities for small-scale farmers to take advantage of larger farms and processing facilities nearby through arrangements such as contract farming.

Sophisticated technologies such as irrigation systems, artificial lighting, hydroponics and digital information systems require capital investment and special skills; only larger commercial operations can afford these. In countries such as Kenya and Ethiopia, growers raise green beans and other vegetables in greenhouses and export them by airfreight to dealers in Europe. However, even smaller-scale producers can adopt technologies such as greenhouses and drip irrigation.

Inputs

Production and marketing technologies

Technologies have been developed that make the production, processing and marketing of fruit and vegetables more efficient. These include the following.

- **Production:** tissue culture and grafting for seedling supply, high yielding and disease-tolerant cultivars, grafting, precision agriculture, drones, extension advice systems, irrigation, greenhouses, insect-breeding for pollination and pest control, pest identification and management, conservation-farming techniques.
- **Harvest and postharvest:** harvesting, sorting and packing equipment, improved packaging and storage techniques (see Chapter 5).
- **Marketing:** market information systems, digital communications, traceability systems, remote payments (see Chapter 4).

These technologies not only increase productivity, yields and quality; they also reduce losses, cut the amount of the labour required, and place greater emphasis on management skills. They are also more likely to attract young, better-educated people to the horticultural professions and create new business opportunities both on- and off-farm. However, they involve capital outlays that may be beyond the reach of poor small-scale producers.

Quality seeds and planting materials

Annual crops such as cabbages and onions rely on quality seeds or other planting materials to produce high yields. Perennials such as citrus, apples and grapes depend on clonal seedlings or grafted cuttings. These planting materials must be genetically pure, have a high germination rate, and be disease-free. Varieties must be adapted to the local environment and to market preferences in terms of colour, shape and taste. And they must be available for the market in different forms: fresh, dried, canned, juiced or fermented (FAO, 2001).

In many countries, quality planting materials are not easily available. Suitable improved cultivars either do not exist or are in short supply. Tissue-culture programmes to produce planting materials are few. Farmers fall back on seeds they have produced themselves, or exchange planting materials with their neighbours. This has advantages (it conserves local varieties) and disadvantages (farmers cannot get the varieties they need to boost their harvest). These drawbacks result from inappropriate policies and the lack of a conducive environment for a thriving seed sector (Tata *et al.*, 2016).

Water

Many fruit and vegetables differ in their water requirements: they need the right amount of water at the right times. Too much water causes root rot. Too little, and they wilt. Gardeners say that tomatoes are particularly

finicky: they need “dry heads and wet feet”. Irrigation is often needed to supplement rainfall (and of course is indispensable in greenhouses). But irrigation water in some areas and seasons is scarce, leading to efforts to get “more crop per drop” (FAO, 2003).

Many small-scale farmers use watering cans to water their vegetables: this is practical in small greenhouses and in gardens close to the house. In larger areas, various irrigation systems are used, using overhead systems, furrows or drip-irrigation (pipes with tiny holes that allow water to dribble out, Wainwright *et al.*, 2013). Irrigation can use “grey water” from washing (after simple filtration), but using “black water” that contains faecal matter is a problem as it may contaminate the soil and crops. Sophisticated systems use biological filtration to recycle water and reduce contamination.



Fertilizers

In places where fruit and vegetables have a low priority, little investment has been made by either governments or the private sector in ensuring that farmers can obtain and learn about suitable fertilizer formulation, proper placement and recommended dosages. As a result, many farmers cannot get the expected yields. The types and amounts of fertilizer applied should be determined based on soil analysis; excess applications should be avoided.

The supply of synthetic fertilizers could be improved through bulk procurements by farmer groups, and by “smart” subsidies and credit schemes to help farmers buy the inputs they need.

Compost is important in fruit and vegetable production, and applying it is

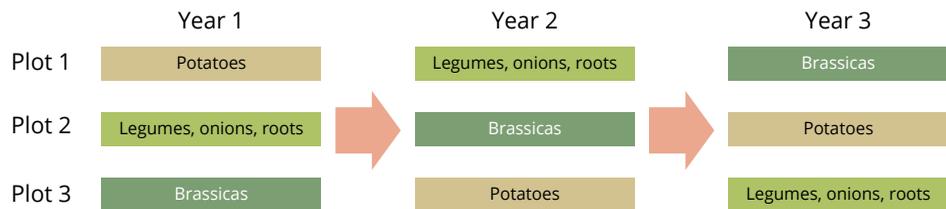
more practical than for cereals because the areas involved tend to be smaller. Many small-scale farmers know this already: they compost their farmyard manure to fertilize their vegetable patch rather than spreading it thinly over their crop fields. Mulch is useful to cover the soil, conserve soil moisture and suppress weeds.

Pest and disease management

Perfect papayas, beautiful bananas, the choicest cherries: many types of fruit and vegetables must appear flawless to be saleable. But many are hypersensitive to pests and diseases. The tiniest blemish can demote them from Grade A to the animal-feed bin.

To avoid this, farmers often apply more chemicals than they need in

Three plots, 3-year rotation



Four plots, 4-year rotation

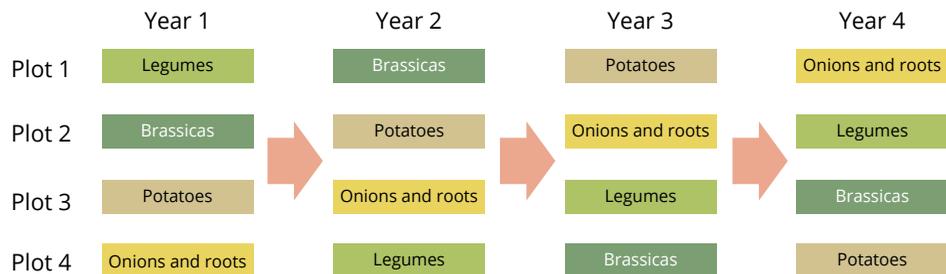


Figure 8. Recommended crop rotations for vegetables in the UK

Adapted from RHS (2020)

order to control pests and diseases and fulfil their buyers' requirements. Indiscriminate and excessive use of chemicals cause health and environmental problems for farmers (Tsimbiri *et al.*, 2015), harm beneficial insects, and contaminate the product, resulting in food-safety concerns.

Integrated pest management is the solution. This is an ecosystem-based strategy that focuses on preventing pests and disease in the long term through a combination of biological control, habitat manipulation, improved cultural practices, and the use of resistant varieties. Farmers use pesticides judiciously and only if careful field checks show they are needed – not as a preventive measure, as is all too common (Flint, 2012).

New technologies such as smartphone apps and accredited laboratories now make it possible to identify pests and diseases quickly and recommend ways of dealing with them (Miller *et al.*, 2009). However, agrochemicals companies may use apps to promote the sale of their products, without alerting farmers to other ways to control pests. It is important to reinforce producers' knowledge and critical thinking and enable them to obtain accurate information and technologies to solve problems.

A number of biopesticides are available on the market that are less harmful to the environment, but these must also be used judiciously. Participatory approaches such as farmer field schools have been successful in promoting integrated pest management worldwide.

Good agricultural practices

Improved seed and planting materials, adequate watering and integrated pest management are all part of a set of "good agricultural practices" that farmers should use to grow enough fruit and vegetables in a sustainable manner. Other technologies include:

Crop rotations and intercropping.

Rotating crops helps maintain soil fertility and control pests and diseases. Single-season vegetables can be rotated with staple cereals and other crops. It is important to follow the correct sequence of crops, as some crop species do not grow well next to or after others (Figure 8). Vegetables can also be grown in alternating rows and bands, or between rows of fruit trees. Fruit trees can be grown around fields or on bunds, where they help stabilize slopes.



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Integrated production with livestock. Livestock can be grazed under fruit trees, where they help suppress weeds and fertilize the soil, or on vegetable fields after the harvest. Animals can be fed with crop residues such as discarded cabbage leaves or blemished fruit. After proper treatment, manure can be used to fertilize gardens and fields.

Soil amendments. Amendments such as mulch, compost and lime can suppress weeds, control erosion, and boost fertility. Some amendments (mulch, compost) can be made on-farm (the quality of the compost is important, otherwise it may contain weed seeds). Other amendments, such as lime, may need to be brought in from elsewhere.

Reduced tillage. Farmers plough their soil mainly to control weeds. But

ploughing has many disadvantages: it destroys the soil structure, reduces soil moisture, kills soil organisms, speeds the breakdown of organic matter, and hastens the release of carbon dioxide into the atmosphere.

It is better to reduce the amount of tillage or avoid it altogether, for example by sowing seed in individual furrows or using specialized planting equipment. Transplanting seedlings enables them to get ahead of weeds; dense planting and applying mulch also suppress weeds. So can herbicides, though these risk polluting the environment, harming biodiversity and contaminating the crop.

Organic farming. Organic farming avoids using synthetic inputs altogether, using many of the principles described above (Scialabba *et al.*, 2015). It relies on dense planting and mulching to suppress weeds, close crop sequencing to avoid fallow periods, crop associations to control pests, careful water control, and intensive observation and maintenance. It is particularly suited to small-scale fruit and vegetable growing where gardeners can provide the level of labour and management required.

Many fruit and vegetable growers in low- and middle-income countries are *de facto* organic producers because they have no access to agrochemicals, cannot afford them, or prioritize their staple crops for the little fertilizer they are able to buy. They could benefit from training and advice in crop management and from improved seeds and planting materials.



Environment

Resource use

Nutrient-dense foods such as fruit and vegetables tend to have lower environmental impacts than carbohydrate-rich staples such as cereals (Clark *et al.*, 2019). Per unit of land, water and nutrients, fruit and vegetables are more effective at providing nutritional security than other crops. That can help prevent the expansion of farming into forest areas that are important for biodiversity and carbon sequestration.

Nonetheless, intensive and unsustainable fruit and vegetable production can use excessive amounts of fertilizers and pesticides, which may harm biodiversity and contaminate surface and groundwater.

Climate change

Comparatively little research has been done on the effects of climate change on fruit and vegetable production. Various aspects of climate change may affect fruit and vegetable production: temperature, carbon dioxide concentrations, ozone levels, water availability and salinity. Their effects are likely to vary from place to place. Some are positive (rising CO₂ levels are expected to stimulate plant growth); others are negative (reduced water availability harms it) (Scheelbeek *et al.*, 2018). Many fruit and vegetable species are highly

sensitive to temperature extremes, such as frost during blossoming and heat during flowering. Some crops stop growing if the temperature is not within the appropriate range; others suffer disorders that make them unmarketable: bean pods get stringy, cauliflowers develop hollow stems, and lettuces “bolt” (grow extended stems) (Peet and Wolfe, 2000).

Neglected crops and wild species

Of an estimated 400 000 plant species in the world, somewhere between 30 000 and 80 000+ are edible by humans (Brummitt *et al.*, 2020; FAO, 2018). Several thousand are grown as agricultural and horticultural crops. Some 7 000 species have been gathered and cultivated since the advent of agriculture. But the world’s food supply depends on just 200 plant species (many of which are fruit and vegetables), and only 12 species provide three-quarters of the food we consume; just nine account for 66 percent of total crop production (FAO, 2019; IDRC, 2010). Most of the remaining minor crops are also fruit and vegetables, as are the vast majority of other edible species.

These species and landraces are often referred to as “neglected and underutilized” because they have been “forgotten” by agricultural research and investments. They include traditional crop species and varieties, as well as wild species that people often also harvest and use as food. They present enormous untapped potential for small-scale

farmers and rural communities. They are often more nutritious and more resistant to pests and diseases than are commercial varieties (Schreinemachers *et al.*, 2018). They are well-adapted to the local climate and pests. They are resilient and require few or no inputs, often growing as weeds in and around fields and along roadsides, so are typically accessible for both landowners and the landless.

Many traditional crops and wild species are sold in local markets (Mundy, 2014). They help maintain food and nutrition security and act as a buffer in disaster-prone areas (Rahim *et al.*, 2009). Such species and varieties can be developed to broaden the food basket in face of the threat of climate change (Padulosi *et al.*, 2013). Wild foods contribute to dietary quality, dietary diversity and seasonal evenness (Powell *et al.*, 2015), providing important nutrients and complementing many staple-based diets in any given month of the year.

It is important to develop strategies that can help indigenous food crops to effectively contribute to food security, nutrition, health and economic development (Kahane *et al.*, 2013). This will require the creation of favourable policy environments and increased investments (Jaenicke, 2013), production and dissemination of information (Pichop *et al.*, 2016), and promotion of research, knowledge management and capacity building, e.g., to promote breeding programmes focusing on the development of adapted varieties (COAG, 2018).

Crop biodiversity

Farmers and gardeners around the world maintain a wide range of traditional varieties of fruit and vegetables. But this wealth is under threat from various sources. Commercial pressures induce farmers to adopt high-yielding types instead of lower-yielding but hardier traditional sorts that have limited consumer demand. Seed producers market only commercial varieties – often hybrids that produce useless seed or no seed at all. When older varieties of fruit trees die, they are not replaced. Cross-pollination with imported varieties dilutes the genetic purity of local types. Pests, diseases, drought and heat take their toll on the remaining populations of traditional varieties and may force them into extinction.

In high-income countries, seed companies breed, multiply and market seeds of horticultural crops, and commercial nurseries raise seedlings of vegetables and fruit trees. Universities, research institutes and nongovernment organizations also conserve and distribute seeds of traditional varieties. Such services are rare or non-existent in low- and middle-income countries – except for a few commercial species such as bananas and pineapples. Farmers must rely on their own seed or on local seed exchanges. This conserves biodiversity, but means that farmers do not have access to suitable higher-yielding varieties.

The World Vegetable Center, the international research institute with the mandate for vegetables, maintains

a genebank with 61 000 accessions from 155 countries, including about 12 000 accessions of indigenous vegetables (World Vegetable Center, 2020b). But much less work has been done to characterize and conserve the germplasm of most fruit and vegetable species than for the major staple crops. The International Rice Genebank, by contrast, holds more than 132 000 accessions of rice and its wild relatives (IRRI, 2019a).

Policies and institutions

Sustainable intensification of fruit and vegetable production calls for political commitment, investment, institutional support and a demand-driven approach to technology development. There is no “one-size-fits-all” set of recommendations. Still, it is possible to identify the key features of enabling policies and institutions for sustainable intensification of small-scale fruit and vegetable production. The design, implementation and monitoring of policies will require strong collaboration between different ministries and administrations, from public health and education to trade, environment and agriculture.

Research and technology development

Compared to major staples such as rice and wheat, relatively little public effort has gone into developing improved technologies for fruit and vegetables. This is because in the past, governments and international



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organizations have focused on ensuring food security in terms of calories rather than in terms of nutrients: they have put more effort into filling plates rather than increasing the variety of food on the plate. It is also because of the sheer number of fruit and vegetable species, each of which needs its own breeding and research programme.

The funding devoted to research on all types of crops is inadequate given the importance of these crops, the challenges facing them, and the proven and potential payoff of research and development. The International Rice Research Institute has a budget of USD 73 million and focuses on a single crop (IRRI, 2019b). That is still far more than the budget of the equivalent institute devoted to vegetables, the World Vegetable Center, which has a budget of around USD 20 million and must deal with a whole basketful of crops (World Vegetable Center, 2020a). There is no international research centre focusing on fruit.



agricultural research effort, and most horticultural research focuses on the major commercial and export crops, such as bananas, rather than on the wide range of crops that are locally important and do not appear in trade data. More research is needed to support sustainable domestic production and the conservation and promotion of neglected and underutilized species, especially in regions where projected supply is particularly inadequate, such as sub-Saharan Africa, parts of Asia and the Pacific (Mason-D’Croze *et al.*, 2019).

Research is needed to breed varieties with disease- and pest-resistance, tolerance to heat, drought, flooding and salinity, and with increased nutrient content. Other priority topics include crop-management techniques, the control of pests and diseases, water-efficient irrigation methods such as drip irrigation and recycling of used water, good soil management and conservation methods to enhance plant health, and the use of appropriate farm machinery to reduce labour needs and improve productivity.

The majority of agricultural research is performed by public institutions such as government research institutes, universities, and international centres (Beintema and Elliot, 2011). Figures on private-sector research are difficult to find but appear to be lower than publicly funded research. Most private research focuses on high-income countries, with very little going to low- and middle-income countries.

Fruit and vegetables account for a small proportion of the total

Greenhouses offer many opportunities to lower the environmental impact of growing vegetables, for example by optimizing energy use, reducing the emission of CO₂, improving the efficiency of water use, and controlling pests and diseases.

But small-scale producers grow most of the world’s fruit and vegetables, and technologies are needed that suit their conditions and their pockets. Women, who manage a big share of the world’s gardens, must be ensured access to

new techniques. The development and deployment of such technologies offer business opportunities for youth employment on- and off-farm. Further along the value chain, technologies are needed to improve postharvest services, storage, transport and processing in order to preserve nutrient content and taste, and to reduce losses.

Extension services

Like agricultural research, extension services are generally focused on major staple and cash crops. Most extension workers are trained in the major crops first and other topics second; when they meet farmers, the big crops take up the biggest part of the time.

Nonetheless, fruit and vegetables pose very different problems for farmers at all stages – inputs, production, harvesting and marketing. Each crop presents its own challenges, suffers from its own pests and diseases, and must be marketed in its own way. Extension personnel need to be able to advise farmers on all these topics.

The internet and smartphones enable producers to learn about various aspects of production and marketing, as well as to discover prices, link with buyers, and make and receive payments. They also make it easier to gather, collate, analyse and report data on areas, production, yields and prices. While commercial farmers in high-income countries typically obtain information and fill in forms on a computer, smaller-scale farmers and

those in low- and middle-income are more likely to use their smartphones. Both government and private operators are developing services for farmers, typically focusing first on staples and cash crops such as cacao and coffee, but also covering major horticultural crops such as tomatoes.

The advent of smartphones presents new opportunities (it is possible to communicate with farmers without having to travel) but reinforces old problems (how to reach the poorest farmers, especially women). Private operators also face the problem of finding ways to pay for their services: advertisers are scarce in poor areas, and farmers are unwilling or unable to pay for subscriptions (CTA, 2015). Connectivity and internet facilities in rural areas need to be improved before connected devices can be used. This is especially important with the recent upsurge in online marketing activities.

Rural infrastructure

The infrastructure needed for fruit and vegetables also poses challenges. A few species, such as onions, are relatively robust and can be tipped into sacks or loaded onto lorries in bulk. Others, such as tomatoes, mangoes and soft fruit, are extraordinarily delicate and must be handled with great care. They require careful sorting and grading to remove damaged fruit, special packing to protect them on the road, and refrigeration throughout their journey to keep them in tip-top condition. They do not take kindly to being bounced

on the back of a truck bumping along a corrugated dirt road.

Investment in roads, electricity (for cold rooms), internet access, warehousing and processing capacity in production

zones will help link farmers to markets for fresh produce and to processors that convert them into products with a longer shelf life. This will also help stabilize prices, reduce postharvest losses and lower transaction costs.

Markets and value chains

4

Responding to health-conscious consumers

The fruit and vegetables sector plays an important role in providing fresh and nutritious food to consumers around the world, especially in growing towns and cities. The sector generates income not only for producers, but also for the actors along the value chain that links farms to consumers (FAO, 2018). Fruit and vegetables can generate high returns per hectare, making it possible to reduce poverty if the right investment, capacities and services are in place.

This chapter examines various aspects of markets and value chains, including international trade, the links between farmers and domestic markets, and the need for responsible business practices.

International trade

International trade of fresh fruit and vegetables represents only around 7–8 percent of total global production (FAOSTAT), but it still ranks among the most valuable crop and livestock commodity groups (Figure 9). Exports are an important driving force behind the expansion of the fruit

and vegetables sector, and they also stimulate domestic production and markets. The growth in exports has significantly outpaced the increase in production: global trade more than doubled between 2000 and 2018 (Figure 10).

While exported quantities of fresh produce are low compared to the produced quantities, the value of trade means that they have the potential to contribute substantially to both the agricultural and gross domestic products of producing countries. Latin

Figure 9. World export value of selected agricultural commodities, 2018

Source: FAOSTAT (2020)

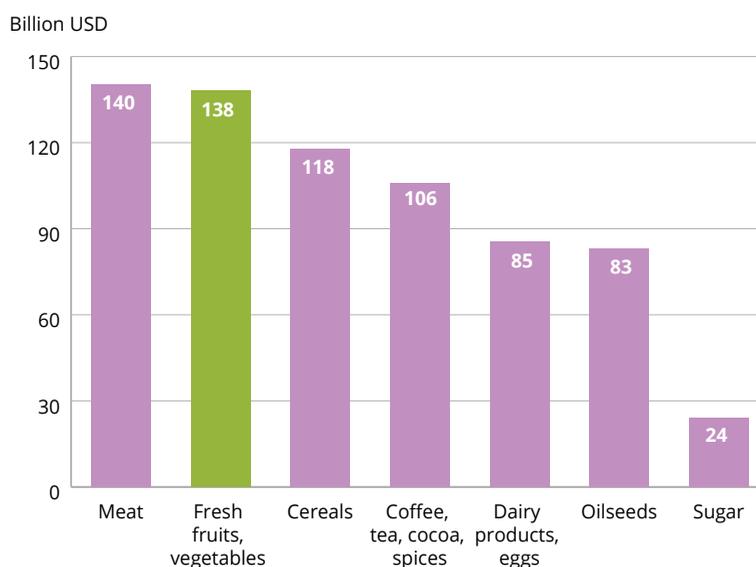
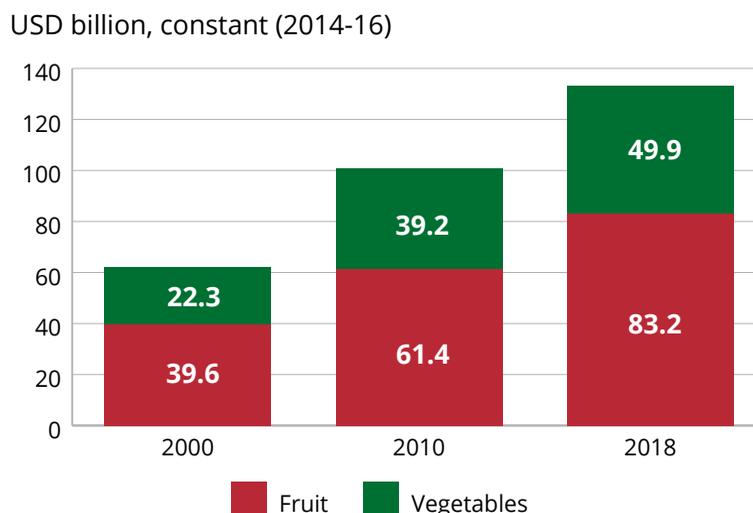


Figure 10.
Worldwide exports of fresh fruit and vegetables: Total aggregate volume increased by 115 percent between 2000 and 2018

Source:
FAOSTAT (2020)



America and the Caribbean and Asia have established themselves as the most important exporting regions, where trade in fruit and vegetables generates important foreign exchange that many low- and middle-income countries can use to import food and other items. Favourable land, climatic conditions and high productivity in many areas of these regions make it possible to produce many varieties on a large scale, and year-round. Many countries in these regions have also invested in institutional capacity development (Fernandez-Stark *et al.*, 2011) and the infrastructure needed to support trade.

Increases in trade have also been made possible through innovations in distribution technology and logistics that have cut transport costs and delivery times. Fresh produce is now available and affordable year-round in many places (Altendorf, 2017). Investments from importing countries in producing countries and bilateral or multilateral agreements have stimulated this trade.

The major importers of fresh produce are the European Union, the United States of America (both are also large exporters), China, Canada, Japan and the Russian Federation. Trade agreements, such as the World Trade Organization Agreement on Agriculture and various regional trade agreements, have led to reduced import tariffs (FAO, 2017b) among other effects, also stimulating growth in trade of the sector (Huang, 2004).

The expansion in global trade is also impacted by rising demand in high-income countries, particularly in the United States and the European Union, the two largest importing blocs. A preference for safe, good-quality, attractively packed fresh produce, a growth in health consciousness, and more widespread awareness of the nutritional benefits of fresh fruit and vegetables all contribute to rising consumption (see Chapter 2).

Campaigns to promote the health benefits of nutrient-rich fruit and vegetables and the growing availability

of ready-to-eat products further stimulate demand. Indeed, changing consumer preferences can be seen in the growing year-round availability of fresh items that were once regarded as highly seasonal. For some high-value products, such as avocado, changes in consumer preferences are a key driver of trade expansion. On the other hand, global demand for some other items, including pineapples, mangoes and papayas, is more sensitive to changes in their price and to changes in incomes in importing regions (Altendorf, 2017).

Trade tends to be dominated by large national and multinational firms (Altendorf, 2019) which capture most of the added value. This may limit the potential of the fruit and vegetable export sector to reduce poverty.

Contract farming is one way that farmers can improve their participation in the high-value fruit and vegetables sector, as the approach provides solutions to address small farmers' challenges related to access to technical assistance, inputs, credit, insurance and market information (FAO, 2015; UNIDROIT, FAO and IFAD, 2015; FAO, 2020d).

Contract farming

The growth in global fruit and vegetable markets opens significant opportunities for farmers, and “[c]ontract farming arrangements are increasingly seen as a means to include smallholder farmers in remunerative markets for added-value foods that are

shaped by urbanization and income growth” (FAO, 2020d).

Contract farming is an agreement between one or more farmer(s) and a contractor for the production and supply of agricultural products under forward agreements, frequently at predetermined prices (Eaton and Shepherd, 2001). Farmers undertake in advance to supply given quantities of a product to a buyer at a guaranteed price. The contract may stipulate the volume, quality and timing, the crop variety, production methods (such as the agrochemicals that may be used), packaging, and other details. The buyer may arrange for training, advice, inputs such as seeds and chemicals, and even specialized equipment and labour for land preparation and harvesting, as well as credit to cover the cost of inputs.

Ideally, both sides benefit: the farmer gets a guaranteed market and income, while the buyer is assured of a reliable supply of a quality product. But contract farming carries risks



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for both sides. The buyer is often in a more powerful position and may impose demands that are too stringent on the farmers. On the other hand, farmers may not honour the delivery of the contracted amounts or quality standards indicated, or may side-sell to buyers offering a higher price at harvest-time (FAO, 2013).

Whether farmers engage in contract farming depends on many factors, including the farmer's own characteristics, the local situation and

farming system, and the needs of the buyer (FAO, 2013, 2020a). A survey of farmers in peninsular Malaysia, for example, found that farmers were more likely to be interested in contract farming for fruit and vegetables if they owned the land they farmed, cultivated a relatively large area, were educated, and believed they would benefit from the contracting arrangements (Arumugam *et al.*, 2017).

Through contract farming, processors, exporters and other midstream actors integrate small farmers into highly profitable national and global value chains. But these are still very limited in scope. Some examples:

- **South Africa.** Citrus growers have contracts with both an exporter and a juice processor and receive financial and technical support (FAO, 2013).
- **Tanzania.** An exporter supports vegetable farmers to meet international quality and safety standards (FAO, 2013).
- **Nepal.** Farmers in remote areas who grow ginger under contract with a processor and exporter report around 58 percent higher net profits than non-contracted farmers (Kumar *et al.*, 2016).
- **Mexico.** A family-owned frozen-vegetables firm offers small-scale producers contracts and provides them with the inputs, technical assistance and credit in a way that minimizes the firm's contracting transaction costs (Key and Runsten, 1999).



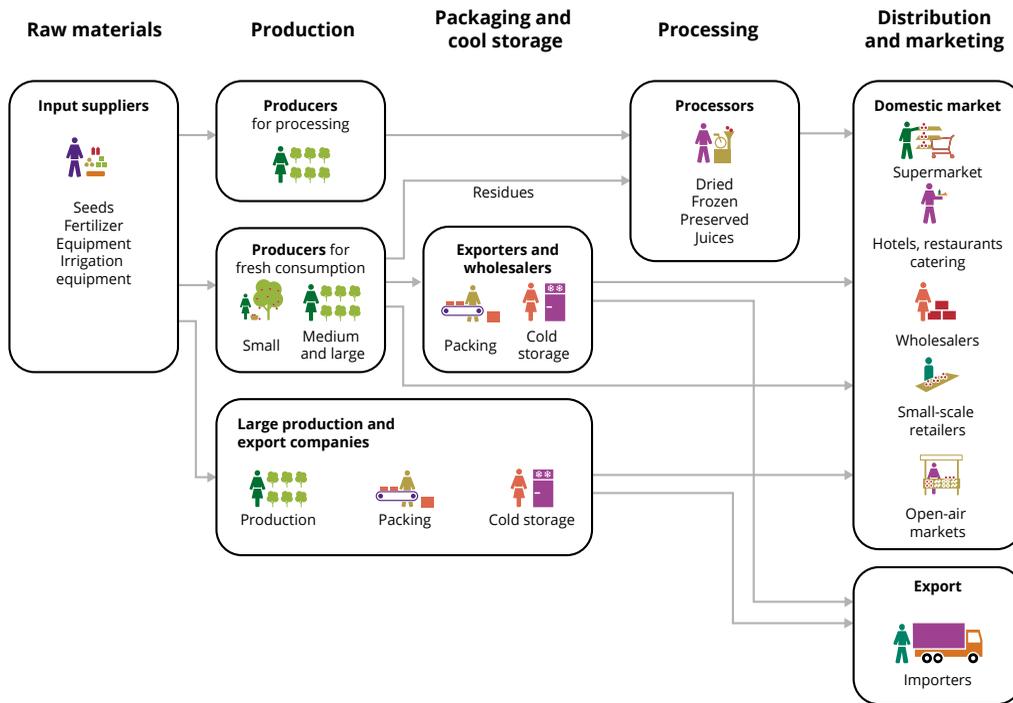


Figure 11. Fruit and vegetable value chain in Ukraine

Source: CBI (2015)

While contract farming is typically applied to procure produce from farmers for export markets that apply stringent requirements on producers (FAO, 2016), there is some evidence that the approach can also be adapted for improving coordination in domestic food markets, including for high-value produce (Meijerrink, 2010; Soullier and Moustier, 2018).

Linking farmers to domestic markets

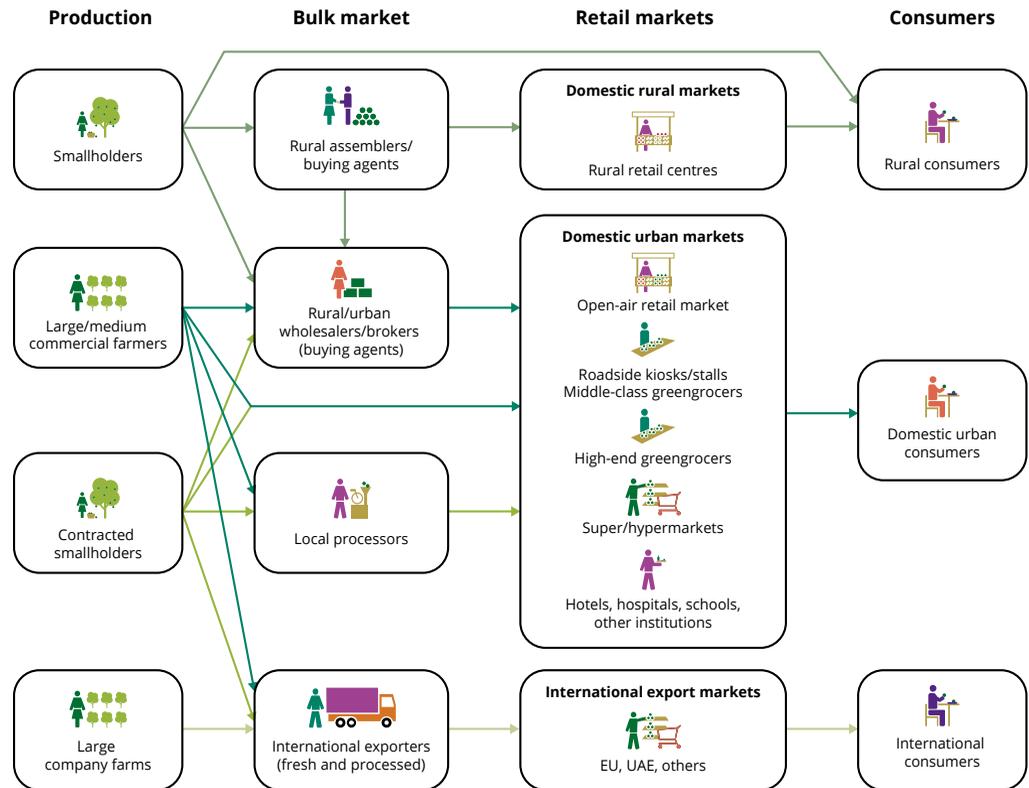
Due to high perishability and competitiveness in export markets, most fresh fruit and vegetables are traded and consumed locally or nationally. In Africa up to 96 percent of marketed farm output (including fruit and

vegetables) is supplied through the domestic market (AGRA, 2019). In Latin America and Asia, most fruit and vegetables are sold through wholesale markets, fresh food markets, supermarkets and specialized grocery stores (Boza, 2020; ADB, 2019a, 2019b, Ren and An, 2010).

Much of this produce is grown by smallholders for sale through an often-complex system of traders and intermediaries, or sometimes directly to consumers (see Chapter 3). Figures 11 and 12 show value chain maps for selected fruit and vegetables in Ukraine and Uganda. The maps demonstrate the complexity of the linkages between the numerous actors along the value chain, and how the relationships and types of actors vary from one country to another.

Figure 12. Avocado, mango and green beans value chain in Uganda

Source: Dijkxhoorn et. al. (2019)



Domestic and regional food markets are expanding in low- and middle-income countries on the back of population growth, urbanization, rising incomes and a growing middle class, increasing women’s participation in labour markets, and shifts in consumer preferences for food. As income growth leads to major socio-economic changes, parallel shifts in food consumption patterns also take place – a process known as the “nutrition transition”. In the last stage of this transition, the consumption of fruit and vegetables increases (FAO, 2020d).

These trends have been taking place in a number of low- and middle-income countries (Pingali, 2007; Popkin, 2006, cited in FAO, 2020d). Governments

can also promote fruit and vegetables programmes, as in India and Brazil, where consumption of mango and papaya has been expanding among an increasingly affluent population (Altendorf, 2017).

These shifting patterns in incomes and food consumption create opportunities for small farmers and small agri-enterprises along food value chains (Reardon, 2015). They give rise to shorter food value chains and distribution channels, creating more opportunities for direct linkages between producers and consumers (Galli and Brunori, 2013). Shorter food value chains may also stem from initiatives such as farmers’ markets or open-air food fairs, which build on

consumers' desire to engage directly with producers. Governments can also promote fruit and vegetable consumption and sustainable production from smallholders through public food procurement for schools and other public institutions (ECLAC *et al.*, 2015). The COVID-19 crisis emphasizes the central role that local food-distribution channels play in ensuring food security (FAO, 2020b).

Value addition

Value addition for fresh fruit and vegetables includes sorting, grading, packaging, transport, wholesaling and retailing, as well as processing activities. It is done by enterprises of various sizes, from micro to large. Some actors perform multiple roles: wholesalers, for example, may play an important role in providing market information for producers and managing postharvest logistics (FAO, 2014). In many countries, supermarkets have a growing share of the retail trade in fresh produce, but the traditional retail sector, which includes local wet markets and roadside stalls, is still central for fruit and vegetable retail and food security in low-income countries (Parfitt *et al.*, 2010).

Strengthening the capacities of the sector can improve market transparency and the quality and safety of food available in domestic markets (Demmler, 2020). In addition, these mid-stream agrifood enterprises also create the biggest market opportunities for farmers domestically (AGRA, 2019).



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As with small food producers, small and medium agrifood enterprises also face a number of obstacles when linking to markets (FAO, 2015).

- **Access to finance** is a longstanding problem for small farmers and agrifood enterprises alike (and not only in the fruit and vegetable sector). The lack of reliable, affordable finance inhibits innovation, growth and employment generation, and constrains the agrifood sector's capacity to reduce poverty (Beck and Cull, 2014; FAO, 2020d; Fjose *et al.*, 2010; OECD 2017).
- **Infrastructure and utilities** such as cold chains, appropriate storage and processing technologies, reliable energy and clean water supplies are often inadequate.

Their development is hindered by a shortage of investment opportunities, qualified staff, inadequate controls, and fragmented supplies (FAO, 2016).

- **Government support for mid-stream actors** is also frequently lacking. Ministries of agriculture and extension services focus on up-stream activities by producers, while small-scale mid-stream actors in the value chain fall between the mandates of ministries of trade, industry and commerce (FAO, 2015). Policies and regulations addressing them overlap or conflict, while policies tailored for the manufacturing sector fail to apply to the agribusiness sector with its special concerns:

product perishability, unreliable procurement, sensitivity to weather, etc.

Learning from international trade

Domestic value chains can benefit by learning from successes in the international trade of fresh fruit and vegetables. Governments can support the sector by providing institutional frameworks for public-private collaboration, investing in infrastructure such as storage facilities and laboratories, stimulating linkages with research to generate innovations in postharvest operations (e.g., packaging and cold chains), encouraging finance for the sector, and building the competence of producers and managers (Fernandez-Stark *et al.*, 2011). In Chile, such support helped the fruit and vegetable sector to upgrade and become competitive internationally, generating more than 450 000 jobs along the chain – equivalent to 5 percent of the country's labour force (López, 2009).

Trade policies that stimulate exports can also affect the behaviour of national actors in the value chain. Appropriate policies can foster open borders and promote responsible, transparent national value chains. In the area of food safety and plant health, the agreements of the World Trade Organization strongly encourage the use of international standards as the basis for national measures. This can help to reduce trade costs and allow food to move smoothly between markets.



Responsible business

Employment and work conditions

Policymakers are increasingly looking to high-value food chains, such as fruit and vegetable value chains, to create off-farm employment (Losch, 2012). In rural Africa, farming accounts for around 40 percent of employment (as measured in terms of full-time equivalents). The wholesale, logistics, processing and retail of food and other agricultural products account for a further 25 percent (Dolislager *et al.*, 2019; Arslan *et al.*, 2019), with half of these activities carried out by small and medium-sized enterprises. As the number of mid-stream firms in food-supply chains grow, expectations are that farm output will be stimulated and on-farm employment created (Reardon *et al.*, 2019). These small rural enterprises are more likely to hire vulnerable groups such as women or young people (Dolislager *et al.*, 2019).

Jobs created in the sector should offer decent employment opportunities (Box 4). But value chains for fresh produce are particularly vulnerable to environmental, social and governance risks. The industry has a relatively high proportion of informal workers (casual, migrant or family labour). It is not uncommon to find farms where workers toil long hours in difficult conditions, without adequate health-and-safety safeguards, and without respect for their rights, such as the freedom to form unions. Child labour has been frequently reported, gender equity is a problem, and gender-based violence is common (Cooper,

Box 4. Decent jobs

Decent jobs are defined as opportunities for work that are productive, respect core labour standards, provide a fair income (whether through self-employment or wage labour) and ensure equal treatment for all. Workers should be able to perform their tasks under safe and healthy conditions and have a voice in the workplace (FAO, 2017a).

2015). Crop production can have adverse environmental impacts, especially on large, monoculture plantations that heavily rely on pesticides to protect crops and agrochemicals to preserve products.

To protect vulnerable groups, employees and the environment, companies operating beyond the farm gate and along value chains need to ensure their supplies are procured from sources that adhere to environmental, social and governance good practices by putting appropriate policies and systems in place. Doing so will protect companies at all levels, from small firms to multinationals, from reputational problems. This in turn can help them avoid costly remedial actions and improve relationships with suppliers, business partners and other stakeholder groups, thereby reducing their costs and raising their profitability (FAO, 2020c).

Due diligence

Drawing on various international guidance instruments (Table 1) and applied throughout the value chain, due diligence and responsible business practices can benefit farmers, farm

Table 1. International guidance instruments on responsible business practices

OECD- FAO	Guidance for responsible agricultural supply chains Organisation for Economic Co-operation and Development and Food and Agriculture Organization of the United Nations OECD and FAO (2016)
CFS	Principles for responsible investment in agriculture and food systems Committee on World Food Security CFS (2014)
UN	Guiding principles on business and human rights United Nations UN (2011)
ILO	Declaration on multinational enterprises International Labour Organization ILO (2017)
OECD	Guidelines for multinational enterprises Organisation for Economic Co-operation and Development OECD (2011)

Box 5. Due diligence

Due diligence is defined as a process through which enterprises can identify, assess, mitigate, prevent and account for how they address the actual and potential adverse impacts of their activities as an integral part of business decision-making and risk management systems (OECD and FAO, 2016).

workers, small agri-enterprises, local communities, the environment and society as a whole (OECD and FAO, 2020). Due diligence by companies can also increase the resilience of value chains to external shocks such as COVID-19 (Box 5).

This chapter has explored recent trends behind the rapid growth in demand for fresh fruit and vegetables, and notably of tropical fruit. The rise in international trade has been enabled by advances in transportation, storage technologies, trade agreements, rising incomes and shifting consumer preferences. However, if the potential of the sector is to be harnessed for poverty reduction, it is necessary that the right support infrastructure, investment and access to services for small-scale actors across the entire value chain be provided, alongside an enabling environment that protects the rights of vulnerable groups. The relevance of consumer trends is also discussed, as well as the importance of learning from opportunities provided by international trade for domestic market development for low and middle-income countries.

Nothing to lose

5

Quality, safety, loss and waste

Food that does not appeal to consumers goes unbought and uneaten. Food that is contaminated by pathogens or chemicals is unsafe to eat – and cannot be counted as food. All along the value chain, starting in the field and ending in the kitchen or dining room, food is lost or wasted. Because they are perishable and fragile, fruit and vegetables are especially at risk of going uneaten (FAO, 2019).

This chapter focuses on four related issues: food quality, food safety, and losses and waste. It outlines the factors relating to each, and how quality and safety can be assured and how losses and waste can be minimized.

Quality

Go into a market or shop anywhere in the world: shoppers will be picking and choosing fruit and vegetables according to their look and feel. They want firm tomatoes, yellow bananas, unwilted lettuce, apples without maggots, blemish-free mangoes, and fresh spinach. Traders constantly sort through their stock to toss

out damaged or overripe produce. Supermarkets package delicate items to prevent bruising and extend their shelf life. Greengrocers spray water on their wares to keep leaves perky and flies away.

By definition, consumer expectations and perceptions will also determine their perception of food quality (Box 6). What may be unacceptable to one consumer may be perfectly acceptable to another. Consumers often assess quality on a subjective basis: their choice depends on their expectations. Firms use quality standards based on objective measurements, driven by data on temperature, firmness, sugar

Box 6. Food quality and food safety

Food quality describes the attributes of a food that influence its value and that make it acceptable or desirable for the consumer. The ideal of food quality therefore differs across countries and cultures.

Food safety is the assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (CXC, 1969). Unlike food quality, food safety is non-negotiable.



content and shelf-life predictions for fresh produce.

Quality is especially important to serve all markets, and particularly high-value markets: exports, supermarkets, hotels and restaurants. Commercial quality standards for fruit and vegetables are developed and approved by the United Nations Economic Commission for Europe through its Working Party on Agricultural Quality Standards (UNECE, 2020). These international standards facilitate trade, encourage high-quality production, improve profitability and protect consumer interests. They are used by governments, producers, traders, importers and exporters, as well as international organizations.

Stakeholders along the value chain emphasize different aspects of quality.

- **Producers** value factors such as yield, resistance to pests and diseases, and ease of harvesting.
- **Wholesalers and retailers** place a premium on size, form, colour and safety. They often require the produce to comply with in-house or industry standards.
- **Consumers** are more interested in the visual appearance, texture, firmness, sensory and nutritional properties.

Factors affecting quality

Fruit and vegetable quality is influenced by extrinsic and intrinsic factors. **Extrinsic** factors include the production environment, how the produce is handled during harvest and

at various stages of the supply chain, and how it is packaged and presented for sale to consumers. **Intrinsic** factors relate to the food itself: its visual appearance (size, form, and colour), texture, firmness, sensory and nutritional properties, and food safety. All these attributes are of interest and value to consumers.

The best type of handling and packaging depends on the type of produce. Bananas, for example, should be kept at a temperature of 12–15°C. Cauliflower needs cooler temperatures (0–5°C).

Because produce continues to respire during storage, it consumes oxygen from within the packaging and emits carbon dioxide, slowing down the ageing process and extending shelf life. But if the packaging is airtight, there will not be enough oxygen left and the produce will die. That is why plastic packaging often has perforations to allow a controlled amount of oxygen to reach the contents (MAP, 2012). Ethylene gas emitted by fruit hastens the ripening, aging and eventually spoilage: putting ripe bananas (which emit a lot of ethylene) next to apples will speed their ripening.

Basis on which consumers purchase produce

Consumers purchase fresh produce on the basis of search, experience and credence attributes (Box 7).

- **Search attributes** are evident from the appearance of the produce itself: the consumer can

Box 7. Quality attributes based on consumer perceptions



Search attributes

Can be checked directly before purchase.

- Colour, size, firmness, blemishes



Experience attributes

Evident only after purchase, but influence whether someone buys the same produce item again.

- Taste, texture, cooking quality



ORGANIC

Credence attributes

Cannot be assessed before or after purchase; depend on credibility of supplier. Often given on labels.

- (Sometimes) food safety
- Organic, fair trade, local origin, pesticide residues

Adapted from Rezare Systems (2020)

see whether a fruit is over-ripe or bruised, and decide not to buy it.

- **Experience attributes** become evident only after purchase: when the buyer bites into the fruit and discovers its eating quality – its taste and texture.
- **Credence attributes** depend on information or claims from the seller: Is it safe to eat? Was the item grown locally? Is it organic? Is it free of pesticide residues? Such information may be included on a label, but fresh fruit and vegetables are often sold unpackaged without



a label. This attribute also depends on consumers' trusting what is printed there, as the consumer can often not verify claims from the seller at the time of purchase.

Standards

International bodies (in particular the FAO/WHO Codex Alimentarius Commission), governments, industry groups, individual firms and non-government organizations set standards or technical regulations to guarantee the quality and safety of produce. These in turn rely on food-control systems with inspections, certification and sanctions for non-compliance. They are designed to

guarantee the safety and quality of produce and assure buyers that it has been produced and processed in a particular way.

Standards and certification are especially useful where there is information asymmetry: where buyers and consumers cannot easily judge the safety and quality aspects of products or production processes. One example is the environmental friendliness of organic produce. This is a "credence attribute" because consumers have no way of checking that an item was actually produced organically (Caswell and Mojduszka, 1996). Certification systems (and the labelling of certified products) aim to provide a verification or a "burden of proof" that given standards have been complied with.

Table 2. Meeting standards and ensuring safety

Codex Alimentarius	The Codex Alimentarius Commission is the central component of the Joint FAO/WHO Food Standards Programme. It develops recommended codes of practice, such as hygienic practices and practices for the processing and handling of foods or food groups. Codex Alimentarius (2020)
GAP: Good agricultural practices GMP: Good manufacturing practices GHP: Good hygienic practices	A set of recommended practices to maintain quality and hygiene in the food chain.
HACCP: Hazard analysis and critical control point system	An approach that identifies specific hazards and measures to control them, so as to ensure the safety of food.
SOP: Standard operating procedures	Detailed, written, accessible description for use by personnel explaining how each operation is performed.
Traceability	The ability to follow the movement of a food through specified stages of production, processing and distribution.

International standards (FAO/WHO Codex Alimentarius Commission).

The Codex Alimentarius, or “Food Code” is a collection of food standards, guidelines and codes of practice that have been developed by independent experts and specialists in a wide range of disciplines to ensure they withstand the most rigorous scientific scrutiny (Table 2).

Established by FAO and WHO in 1963 to protect consumer health and promote fair practices in food trade, Codex forms the basis upon which countries develop their national food regulations. These standards enable firms to trade with each other in confidence that the produce they are buying will be in accordance with internationally recognized

specifications. Codex standards cover the general quality requirements, plus a list of permitted pesticides, the permissible limits of approved pesticides, postharvest treatments such as waxing, labelling and packaging requirements, and permitted levels of contaminants. Without these common standards, international trade in these products would be a lot more difficult.

Business-to-business. Private standards such the BRC Global Standard for Food Safety (BRCGS, 2020) are typically business-to-business arrangements. Such certification communicates assurance to buyers that the supplier is compliant with the quality standard – although sometimes a quality mark is marketed directly to consumers.

Business-to-consumer. Standards related to sustainability or environmental protection typically follow a business-to-consumer model. So too do those directed to niche markets such as organics. Certified produce is marketed to consumers at point of sale, often via a label attached to the product. Labels that list “credence attributes” such as organic or fair trade fall into this category (Box 7).

Where standards are imposed by a government (such as ISO standards (ISO, 2017)) or a nongovernment organization (such as Global G.A.P. (2020)), the consumer can be reasonably confident that the product actually is what the label says it is. But many firms add their own labels that are not subject to independent verification.

Safety

Fruit and vegetables may be rich in vitamins and other nutrients – but what if they are not safe to eat? Then they will not provide any benefits to consumers but may cause them to get sick or even die – they cannot be regarded as food. They may harbour dangerous pathogens or be contaminated with chemicals.

Washing, peeling and cooking can help remove some of these dangers (although peeling and cooking may lead to the loss of some nutrients). But many fruit are eaten unpeeled and raw, as are salads, tomatoes, cucumbers, beansprouts and other vegetables.

Consumers can detect poor-quality fruit and vegetables reasonably easily, so decide not to buy them. This is not the case for food-safety problems, which may go undetected until the produce has been eaten. They may then cause health problems immediately – such as food poisoning by *E. coli* bacteria – or long-term problems, as with heavy metals.

Food-borne diseases

Outbreaks of food-borne diseases can result in catastrophic consequences for consumers and producers alike. Food-safety hazards can result in products being excluded from the market, causing major economic losses and costs for producers, processors and traders. Assuring food safety must always therefore take precedence over achieving high levels of other quality attributes.

Food-borne diseases are estimated to cause some 600 million illnesses and 420 000 deaths around the globe every year (WHO, 2015). The World Bank estimates that diseases resulting from the consumption of unsafe foods cost low- and middle-income countries alone USD 110 billion in lost productivity, lost trade and medical expenses a year (Jaffee *et al.*, 2019).

Such diseases are commonly associated with two major food groups: fruit and vegetables, and animal products (Minnesota Department of Health). Fresh produce containing excessive amounts of chemical residues or exposed to pollution or

microbial contamination has been linked to a series of food-borne disease outbreaks around the world over the last few years (Hussain and Gooneratne, 2017). Fruit and vegetables that are eaten raw, and especially those that are not peeled or washed in clean water, can transmit pathogens and dangerous chemicals (WHO, 2005). Public concern about these risks is at an all-time high.

Safety controls

Safety controls protect both consumer health and business interests by ensuring that traded produce complies with food-safety standards and that it is safe to eat. Because produce can be contaminated all along the value chain, controls are needed at each stage (Table 3).

Good practices. In addition, FAO issues recommendations for good practices in agriculture, manufacturing and hygiene for fruit and vegetables. These aim to help farmers, traders and processors achieve the standards set out in the Codex Alimentarius.

Standard operating procedures. These are written, detailed and accessible descriptions explaining how each operation should be performed. They assure that operations (including maintenance, sanitation, pest control and waste handling) are efficiently and appropriately performed.

Hazard analysis and critical control points. This system, known as HACCP, is based on one developed by the

Table 3. Food safety risks along the value chain

Stage in chain	Possible sources of contamination
Production	Soil Wildlife, pests Nearby pollution sources Runoff or irrigation water Manure Pesticides, chemicals Tools Seeds or plants themselves
Harvest	Equipment, containers Contact with the ground People
After harvest	Equipment Containers, packaging Storage rooms Washing, waxing People, animals, pests Transport

Source: FAO (2004)



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National Aeronautics and Space Administration in the United States to ensure that astronauts were not affected by food-borne diseases during their space missions. Rather than testing the final product, it identifies critical points in the production system, determines the problems likely to occur at those points, and eliminates them. This is especially important for food products in order to avoid food becoming unsafe for consumption and causing unnecessary wastage.

Traceability. This is the ability to follow (“trace”) the movement of a food product as it passes through specified stages from the producer to the consumer (Box 8).

If a food-safety problem arises, the source can be quickly identified and batches from the same source removed from the market. Traceability also makes it possible to provide

reliable product information and guarantee authenticity – for example for organic or regional produce.

Responsibility for food safety

Various stakeholders share responsibility for food safety.

National governments are responsible for establishing a national food-control system with appropriate legal and policy instruments, well-qualified human resources, sound institutional frameworks and the financial assets, equipment and infrastructure for them to carry out inspections. They also enforce compliance and issue penalties for violations or non-compliance.

National Codex Committees facilitate the aligning of national regulations with the Codex, provide coordination among national stakeholders, and contribute to the development of Codex standards and related texts.

National governments are also responsible for ensuring the supporting infrastructure is able to supply adequate quantities of safe fruit and vegetables. This includes roads for market access, water supplies, power for equipment and cooling systems, access to laboratories and suitable storage facilities.

The private sector, from producers to retailers, is responsible for ensuring compliance throughout the food chain and the necessary facilities, systems, tools and well-trained staff to achieve this.

Box 8. Innovations in traceability

Traceability is a must-have in fruit and vegetable supply chains to mitigate and manage risks associated with food-safety recalls.

New traceability practices that use digital technology help ensure food safety and quality, optimize supply chains and reduce loss by making spoilage problems readily detectable (WEF, 2019).

Blockchain is an increasingly popular method of traceability because it connects all the stakeholders’ digital records and events in a tamper-resistant format. The information can be accessed at any point from anywhere, yet it cannot be edited or deleted.

FAO and WHO provide guidance, scientific advice and build capacity in support of food safety and quality, including supporting countries in establishing and/or strengthening national food control systems.

Codex Alimentarius develops internationally recognized food standards (for specific fruit and vegetables in fresh and processed form), associated Recommended Codes of Practice, as well as guidance on labelling, packaging and transport (CXC, 1995, 2003).

Weak links in the chain

Inspection, certification and enforcement. Food safety inspection and certification, which are part of the official food control system, are not always adequate. Problems include a lack of effective communication and coordination mechanisms resulting in duplication and/or gaps, appropriately trained staff, equipment and transport, poor enforcement and an inadequate legislative framework. At the higher end of the market, private entities impose their own standards, which smallholders may find hard to comply with.

Local trade and home consumption. Many fruit and vegetables are either traded locally or are eaten by the people who grow them. At the consumption end of the value chain, formal standards are often not enforced and it is left up to consumers or traders to reject substandard produce. But this may not happen

because it is impossible for them to detect food-safety problems merely by looking at the produce on offer. At the same time, growers may not realize that they are the cause of contamination because of inappropriate use of chemicals or contaminated irrigation water. Even if they do know this, it may be in their interests to keep quiet about it so they can sell their output and earn an income for their family.

Consumer behaviour. Peeling fruit and vegetables or washing them in clean water can help remove or reduce contaminants on the surface. But access to clean, potable water is not universal. Nonetheless, information campaigns to encourage hygiene at point of use could go a long way to making these nutritious products safe for consumption.



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Loss and waste

Huge amounts of food are lost or wasted every year. This is particularly true of fruit and vegetables because most are highly perishable. Loss and waste of fruit and vegetables represent a waste of nutrients.

Food loss and food waste are not the same thing (Table 4). Postharvest **food losses** take place in the supply chain from harvest until arrival at the wholesale market. **Food waste** takes place mainly in retail, in the food-service sector and in households.

How much is lost or wasted?

A synthesis (FAO, 2019) of numerous studies measuring loss and waste in fruit and vegetables in three world

regions found that postharvest losses were high in both East and Southeast Asia and in sub-Saharan Africa (the coloured bars in Figure 13), though with different emphases (the “critical loss points”, Box 9). In East and Southeast Asia, loss was highest during storage (with a median of over 20 percent lost) and processing and packaging. In sub-Saharan Africa, the highest levels of loss occurred on the farm and in wholesale markets. Loss and waste in Central and South Asia tended to be lower, with loss during transport being the highest.

These median figures mask huge variations. Some studies have found that up to 50 percent of the fruit and vegetables are lost during storage (in East and Southeast Asia) and on farm (in sub-Saharan Africa) (these are shown as the T-lines in Figure 13). These findings imply that there is a

Table 4. Food loss and food waste

	Definition	Stage in value chain	Examples
Food loss	The decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the supply chain, excluding retailers, food service providers and consumers.	Postharvest, processing, distribution	Produce infested pre-harvest; produce damaged during transport Decaying produce in the supply chain due to improper handling
Food waste	The decrease in the quantity or quality of food resulting from decisions and actions by retailers, the food service sector and consumers.	Mostly retail and consumption: households and the food service sector	Uneaten food thrown away in houses and restaurants Produce that is discarded because it fails to meet market standards in retail

Source: FAO (2019)

major potential for improvements in value chains in all regions.

Causes of loss and waste

Loss and waste are systemic and take place along the food supply chain from postharvest to retail. Loss is highest in developing countries and results from a lack of technology and infrastructure (FAO, 2019) and a weak knowledge base of supply-chain stakeholders. At the retail and consumer stages, behavioural issues, inappropriate storage and excessive handling of fruit and vegetables in retail are more often the cause of waste.

High levels of qualitative and quantitative loss occur in low- and middle-income countries where farms and rural activities are poorly

Box 9. Critical loss points

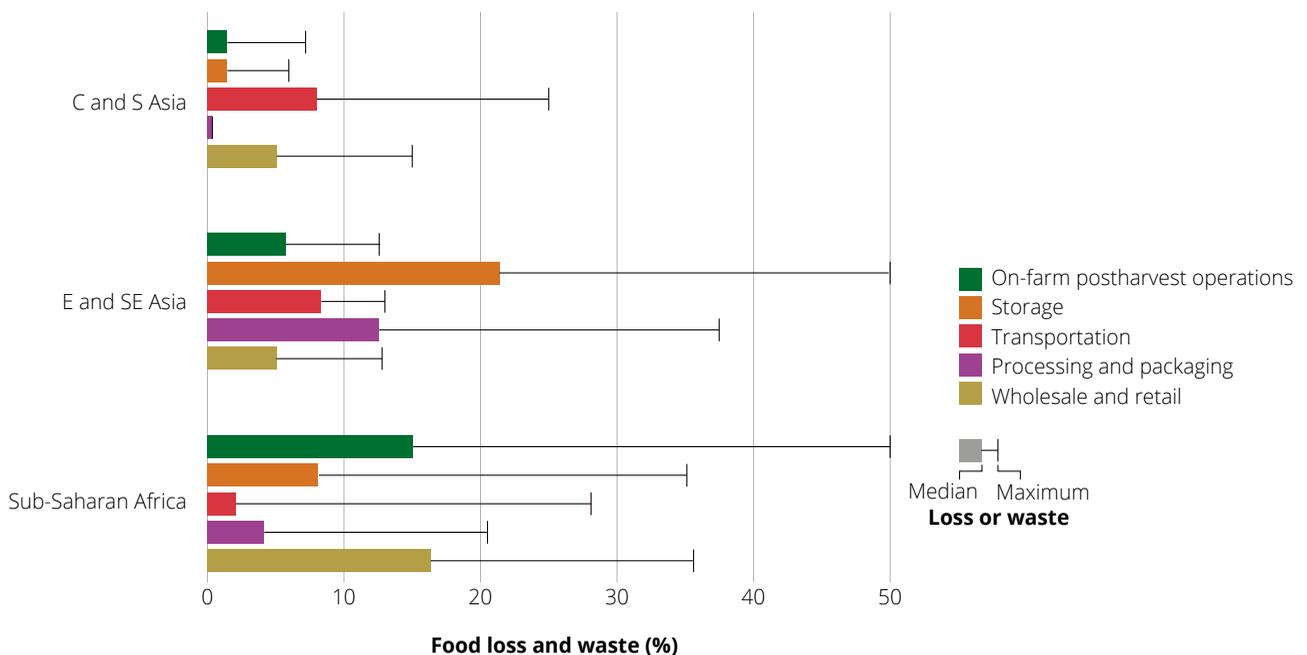
Critical loss points are the points along the food supply chain where food losses have the highest magnitude, the greatest impact on food security and the largest economic dimensions (FAO, 2019).

organized and apply rudimentary technologies and approaches. The loss sustained by smallholders in these countries is caused mainly by the poor functioning of the supply chain.

Problems include limited technical capacity, poor production and handling practices, inadequate infrastructure such as feeder roads, potable water, electricity and packhouses, as well as packaging, transport and storage capacity, and the institutional and legal framework.

Figure 13. Loss and waste of fruit and vegetables

Adapted from FAO (2019) p. 26. Based on 660 observations. Excludes outliers.



Box 10. Reducing loss in mangoes

Transport is the critical loss point in the mango value chain in the Philippines, a study by the University of the Philippines at Los Baños found (FAO, 2020).

Forms of mechanical damage included cuts and punctures (1 percent), compression (1.9 percent), abrasion (2.8 percent), bruising (2.0 percent) and marking from the bamboo baskets (3.8 percent) in which mangoes are transported to wholesale markets. After 5 days in retail outlets, up to 90 percent of mangoes showed mechanical damage. Decay and economic loss were the results.

Improved packaging reduced such problems. Using rigid plastic crates instead of bamboo baskets reduced damage and loss and improved quality available in the market as well as the shelf life of mangoes.

Poor bulk packaging results in loss during transport (Box 10 and FAO, 2017). Without shade or refrigeration, yeast and mould cause produce to spoil quickly in hot, humid climates.

Food that is contaminated and does not meet safety criteria is not fit for human consumption and must be disposed of. Produce that appears visually perfect may be contaminated microbiologically, so present a risk to the health of the consumer.

Food waste may result from stringent commercial quality standards at the retail stage that emphasize aesthetic appeal. “Ugly fruit” are rejected even though they are perfectly sound and fit for consumption from a nutritional and safety point of view: bent cucumbers, green beans that are not perfectly even, and tomatoes that are not evenly ripe.

Impacts of loss and waste

Most obviously, malnourished children stay hungry if they do not have access to food. High rates of loss and waste represent a waste of nutrients, a waste of money and lower profits in production and the value chain, lower incomes for producers, and higher costs for consumers. Smallholder producers and consumers who have little money to spare are especially hard hit.

Food that is contaminated – whether by pathogens, toxins or chemicals – may appear to be of good quality but must be discarded as it may pose a health risk.

Loss and waste also translate into wasted inputs, land, water, energy and other resources used to grow, process and handle the produce, boosting the emission of greenhouse gases that contribute to global warming. Many consumers do not realize that food waste is related to such concerns.

Reducing loss and waste

Postharvest management seeks to manage and maintain the quality of food after harvest and to reduce loss. In the traditional supply chains that predominate in developing countries, fresh produce must be harvested at the appropriate stage of maturity, sorted to remove decaying produce, washed if appropriate, dried, and properly packaged for transport.

Postharvest treatments, such as hot-water and vapour-heat treatments, can

reduce pre-harvest pest and disease infestations in specific crops such as mangoes and papayas. Customers themselves also need to reduce waste by planning their fruit and vegetable purchases and storing them properly (Esguerra *et al.*, 2017).

Fresh produce is best packaged in rigid containers to reduce mechanical damage (Rapusas and Rolle, 2009). During transportation, air must be able to flow through the produce, while minimizing water loss that can cause wilting or shrivelling, weight loss and a decline in quality. Improved packaging and transport reduce mechanical damage, limits the need for handling, and speeds up delivery to retailers and consumers. On arrival in wholesale markets, the produce must be sorted, and re-packaged in accordance with customer demand.

Cooling during transportation can slow the growth of certain microorganisms, reduce spoilage rates of good quality produce, lengthen shelf-life and reduce losses and waste in fruit and vegetables.

Traceability is a must-have in fruit and vegetable supply chains to mitigate and manage risks associated with food-safety recalls. New traceability practices that make use of digital technology help ensure food safety and quality, optimize supply chains and reduce loss by making spoilage problems readily detectable (WEF, 2019). A growing array of sensors that monitor temperature and other metrics in real-time during transportation, will contribute greatly to assuring the safety and quality of food as it transits across supply chains.



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Non-compliance with established food safety measures may lead to higher levels of losses in trade, for example if food is rejected because pesticide residues exceed contamination limits. In a world where 690 million people go to bed hungry every night and three billion cannot afford a healthy diet, wasting food on the basis of aesthetics is ethically unacceptable. Consumers should be given the option to buy “ugly produce” that is safe but does not meet aesthetic standards. Such items are just as nutritious as food that is cosmetically more attractive. Selling them at a lower price would particularly benefit poorer consumers.

Solutions include incentives to support technologies to improve handling, public-private partnerships to support infrastructure and marketing problems, innovations to upscale good practices, and training for stakeholders in the supply chain.

The increasing importance of supermarkets in much of the world will force producers to conform to quality

standards – although consideration is increasingly being given to relaxing these standards in order to reduce waste. Nevertheless, the high levels of waste in retail must not be overlooked, particularly during the current COVID-19

pandemic. At the same time, efforts are needed to ensure that smallholders can benefit from market opportunities and can supply the volumes and quality of produce they demand.

Food for thought

6

Issues for action

Improving nutrition across many regions of the globe hinges upon increasing fruit and vegetable intake as key constituents of healthy diets. Increasing consumption could lead to a win-win scenario for the health of both people and the planet if it is accompanied by concerted efforts and investments to increase production and productivity in the sector. At the same time, however, such efforts need to decrease the environmental footprint, improve harvesting, handling, storage and distribution to reduce loss and waste, maintain quality (particularly nutritive) and increase shelf-life, and educate consumers on the health benefits to be derived from increased consumption of fruit and vegetables.

Every country faces unique challenges based on the environmental, economic and social circumstances in which its fruit and vegetable sector operates. Low consumption, however, continues to be an issue, even in countries where availability is not a constraint. This is mainly related to the affordability of fruit and vegetables. Increasing productivity could reduce the resource intensity

of production and lower the costs to consumers and the planet. Reducing loss and waste in value chains can also reduce the environmental footprint and, if properly implemented, save consumers money. Conducive policy grounded in data, partnerships and capacity development will be key to promoting the sustainable production and consumption of fresh produce.



Policy

Public policy has the power to influence all levels of the fruit and vegetable value chain, thereby shifting production and consumption patterns. These policies might address:

- Creation of a healthy food environment by making options for consuming more fresh produce easier for consumers. This can include awareness-raising campaigns designed to change consumer behaviour, together with the various interventions listed below.
- Formulation of food-based dietary guidelines that promote the consumption of fruit and vegetables as part of a diverse and healthy diet.
- Use of public procurement policies that promote healthy diets.
- Integration of nutrition in school curricula and school meals programmes based on the local and smallholder agriculture production to promote life-long positive nutrition behaviours.
- Subsidies and tax incentives for the production (including sustainable seed provision) and marketing of fruit and vegetables.
- Creation of an enabling environment that supports small-scale producers in supply chains and equitable and sustainable contract-farming arrangements.
- Promotion of biodiversity to enhance nutritious diets by encouraging the usage of locally adapted varieties, landraces, wild crops and indigenous food species.
- Better management and reduction of pesticides in production, supported by effective regulatory processes and knowledge about non-toxic plant-protection products and measures. It is also critical to prevent the illegal trade and use of unregistered pesticides.
- Support for measures to enable the exchange of planting materials among countries.
- Ensuring that policies facilitate the trade of safe food in order to increase access to fresh produce in all locations and during all seasons.
- Reducing food loss in supply chains. In low-income countries, policy options might include strengthening the capacity of producer organizations and increasing investments in infrastructure – roads, potable water, packing houses, cold-chain development – to support postharvest handling and distribution operations.
- Reducing food waste in supply chains. In high-income countries, where food waste is an issue, possible policy options might include adjusting marketing standards for fresh fruit and vegetables, and supporting their gleaning in fields for redistribution by food banks.

- Support to research, development and innovation toward enhancing efficiency and sustainability in fruit and vegetable value chains.

Data to underpin policy development

Innovation and investments in the sector have the potential to transform fruit and vegetable food systems in ways that could sustainably boost productivity and enable more equitable consumption.

Successful policies and investments require data. A holistic and integrated policy agenda informed by data at each step of the value chain will help to balance supply and demand and to combat malnutrition. Requirements include:

- More specific production data for a better understanding of the contributions of small-scale producers.
- Data on where losses and waste in supply chains are most significant (and what causes them). This would indicate the level and scale of technologies needed, guide remedial actions, and help ensure affordability of the fresh produce.
- Research and conservation of indigenous fruit and vegetables, especially those that are not annual crops, as they can contribute to improving diet quality by providing nutrient-dense foods while supporting climate-change adaptation.

Multi-sectoral approaches and partnerships

The complexity of the fruit and vegetable sector necessitates multi-sectoral approaches among governments, the private sector, civil society, academia and research institutions to encourage and support innovation, technology and infrastructure development. These approaches involve coordination and leveraging private- and public-sector resources toward strengthening the sector. Areas of collaboration might include the following.

- Public-private sector collaboration to develop stronger communication and marketing approaches in support of increasing consumption, generating new knowledge on fruit and vegetables, and promoting behaviour change.
- Promoting research and development structures and alliances that enable innovation within the fruit and vegetable



sector to reduce food loss and waste, e.g., the development and use of active and intelligent packaging to reduce spoilage and alert consumers of spoilage.

- Working with civil-society and producer organizations, and forming alliances to build and strengthen global value chains and reducing food loss and waste in supply systems.

Capacity development

Capacity development of stakeholders at all levels of the supply system is critical to assuring the safety, quality, shelf-life and availability of fresh produce in local markets. This will necessitate:

- Capacity development through female and male farmer training on integrating nutrition in good agricultural practices through farmer field schools, demonstration-based training and the use of farmer-to-farmer mentoring. The topics should include integrated pest management, sustainability and food safety along the value chain.
- Capacity development of small-scale producers to enable more direct access to markets and direct farmer-consumer schemes and to facilitate their inclusion in

participatory guarantee systems to enhance marketability.

- Standards, compliance control, and training and education of all stakeholders along the food supply chain on how to produce, harvest, handle, package and transport fruit and vegetables, while maintaining their quality, assuring their safety and reducing loss and waste to meet market requirements.
- Establishment of capacity development and local selection and breeding programmes designed to promote biodiversity in the fruit and vegetable sector, and formulation of food-based dietary guidelines, social and behaviour change communication strategies, enabled by research.

Conclusion

The International Year of Fruits and Vegetables in 2021 provides countries and actors throughout the food system considerable opportunity to act and make a difference within the sector, as well as to promote healthy diets for adequate nutrition. This will facilitate progress in moving toward a holistic approach that will leave no one behind, contribute to eliminating hunger and all other forms of malnutrition toward achieving the Sustainable Development Goals.

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7

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